INSTRUCTIONS

FOR THE USE OF

ESTERLINE-ANGUS MODEL A. W.

GRAPHIC INSTRUMENTS

THE ESTERLINE-ANGUS COMPANY, INC.
INDIANAPOLIS, INDIANA, U. S. A.

SERIAL NUMBER

TR ROUTH CO
1003 CAL. DRIVE
PO BOX 1056
BURLINGAME
CAL

DIAMOND 2-4147
BYRON ROUTH.

NO. 1

RETURN TO
ENVIRONMENTAL TEST
76-18 B/104

INSTRUCTIONS FOR ESTERLINE-ANGUS

Model AW Operation (Event) Recorders

An Esterline-Angus operation recorder is not difficult to service. However, do not use the recorder until you have read this instruction book and have studied the connection diagram. Failure to make connections properly may result in unsatisfactory operation, or permanent damage to vital parts of the instrument.

UNPACKING

Esterline-Angus instruments are carefully packed; carriers are responsible for damage in transit. If the packing case shows damage, make a notation to that effect on your express receipt or freight bill. If it is found that the shipment has been damaged, notify the carrier at once.

Included with each shipment is a packing list showing every item in the shipment. Check off each item as the goods are unpacked, and if any item appears to be missing, go through the packing material carefully before throwing it away. The missing articles may have been overlooked when the packing material was removed.

Each instrument is carefully inspected at the Esterline-Angus factory and then sealed before shipment. New instruments are shipped complete with one record chart, and a box of accessories containing one 2 oz. bottle of red ink, an inkwell filler and a pen filler. Two charts and two accessory boxes are furnished with twin instruments.

DESCRIPTION

Operation recorders are fully described in Catalog Section 50. The Data Sheet in the front of this book and also the nameplate in the recorder, shows whether this instrument is Switch or Voltage Type. Read the portions of Catalog Section 50 dealing with your type of recorder.

OPERATING VOLTAGE

The nameplate in the instrument and the instrument data sheet give the correct operating voltage for the pen units. While the pen electromagnets are designed to operate on 15% over or under rated voltage, best results will be obtained by keeping the operating voltage as near to the rated value as possible. The speed of response of the pens is such that they will follow as many as ten complete "on-off" cycles per second, provided the "on" and "off" times are about equal.

INSTALLING

Front switchboard, wall, and flush instruments should be mounted level in a clean, light place, with the bottom of the instrument about four feet from the floor. The recorder should be mounted where it will not be subjected to vibration or extremes of temperature. If unusual steam, smoke, moisture, dust or corrosive fumes are present, a protective cabinet should be built around the instrument. Drilling dimensions furnished by the factory should be followed when mounting recorders on panels.

Series resistances for front switchboard and wall type recorders, when required, are housed in separate boxes and marked with the recorder serial number. All separate resistances must be mounted vertically. Never put a resistance box in a small closed compartment or obstruct the flow of air through it.

Cases of portable, front switchboard, and wall type recorders have latches that can be sealed

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with standard meter seals or locked with a small padlock. All flush cases have a door lever handle with a built-in lock. Two keys are furnished with each flush recorder. They are in an envelope taped to the top of the case.

SETTING UP FOR USE

This procedure is described in the chart drive instruction section. Where the procedure for operation recorders differs from other instruments a double set of illustrations has been used. (Figs. 10, 21, 23, 25 and 28, Chart Drive Instructions, IS 20, pages 10, 11, 12.)

CONNECTING

Do not connect the recorder without first referring to the wiring diagrams in this book. Incorrect connections may cause permanent damage to the recorder. All terminals are marked with an identifying number corresponding to the pen number. The marking appears on instrument terminals and on the connection diagram. The Esterline-Angus Company does not furnish the switches or contacts for operation of the pens, but a partial list of sources of these switches is given in Catalog Section 50. The operating voltage and electrical data for the recorder will be found on the nameplate inside of the case at the bottom and on the Data Sheet.

FILLING WITH INK

Remove the inkwell by lifting it up over the pen lifter wire. Then use the inkwell filler to fill the inkwell through the filler hole in the right-hand end of the inkwell cover. Replace the inkwell, being sure that the pen tails engage the lever arms and that the inkwell is firmly in place.

Fill each pen, using the pen filler furnished with the recorder. First lower the scaleplate slightly so all pen points rest on the chart. Compress the bulb of the pen filler, lay the flat side of the rubber tip on the chart, raise the pen element and insert the pen point into the hole in the rubber tip. A pair of tweezers will facilitate lifting each pen point off of the chart and inserting it in the hole in the pen filler. Let the filler draw ink through the pen until you can see ink in the glass tube of the pen filler. Remove the pen from the filler, and let the pen rest on the chart. It should write a clean line when pushed back and forth. When pens are primed properly, they will write for a considerable period without further attention.

INSPECTING THE RECORD

Any length of chart can be pulled from the reroll for inspection of the record. Pull the chart straight out from the reroll. The reroll has a lock system whereby a sudden release of tension on the unrolled portion of the chart will lock the reroll, removing tension from the chart and allowing it to be examined at leisure. To rewind the chart, first pull it forward slightly from the reroll and then let it wind slowly back on the reroll roller.

REMOVING THE RECORD CHART

To remove the rerolled chart, grasp the chart with the left hand and push down the reroll latch on the right end. Pull the chart roll forward, out of the instrument.

To remove the chart roll from the reroll, pull the plug out of the right end of the reroll tube by grasping the edge of the right hand disk. The chart can then be pulled off the tube by holding the disk on the gear end. If the chart sticks on the tube, twist the tube in the direction to unwind the chart as the tube is being withdrawn from the chart.

The chart is then ready for inspection or filing. An Esterline-Angus Chart Inspector is a useful device for routine examination of record charts and its purchase is suggested if a number of charts are to be studied.

FEEDING CHART THROUGH BOTTOM OF CASE

On all instrument cases, except the flush (which requires a special notch in the door) provision is made for feeding the chart through a slot in the bottom of the case. To feed through instead of rerolling, remove the rubber strip at the

lower edge of the case cover. The end of the chart which hangs out of the case should be weighted. A paper clamp is sufficiently heavy for this purpose. Do not pull or jerk on the end of the chart, as this may throw it out of time.

CARE OF THE INKING SYSTEM

Use only Esterline-Angus graphic meter ink. It is made especially to satisfy the exacting requirements of recording instruments. Keep the bottle tightly capped to prevent dirt from getting into the ink. Ink begins to thicken at low temperatures and heat must be provided in the recorder if the temperature stays below 20° F.

The inkwell and pen elements of the operation recorder are made so that any pen element requiring attention can be removed and replaced individually, or all the pen elements can be taken out with the inkwell and both inkwell and pens can be replaced in the recorder in one operation. When taking out the inkwell use the bail handle and hold it by this bail handle to set it back in place. The inkwell should be pushed to the right as far as it will go when removing or replacing it. When the inkwell is in place, springs will hold it in the correct position. Be sure that the inkwell is held firmly in place and that the tails on the pen elements are all engaged with the flat fingers which project out from the electromagnets.

Once per week or every two weeks, the inkwell and the pen elements should be thoroughly cleaned. There are two methods of cleaning; the choice of method is left up to the user. The first method starts with the removal of the inkwell and pen elements from the recorder. Remove the pen elements and pry the cover off the inkwell. Do not damage the pen elements while removing them. Wash out the inkwell, removing all dried ink. Use the rubber pen filler to push water through the pen elements. When both inkwell and pens are clean, replace cover on inkwell by pressing it firmly into the inkwell. Return the pen elements to their places in the cover. Fill with fresh ink and replace both inkwell and pens in the recorder.

The second method enables the user to wash both inkwell and pen elements in the same operation. After removing the inkwell and pens from the recorder, hold the pens in position with the left hand, and pour any remaining ink out through the filler hole in the right end of the inkwell. Direct a stream of water into the filler hole of the inkwell. As the inkwell fills, water will be forced through the pen elements. Continue the operation until the water coming from the pens is clear. The pens may be held under the water for a short time to remove any ink on the points. Holding the pens in position again with the left hand, empty water from the inkwell. Be sure all excess water is removed.

To remove water from the pen elements, lay the inkwell so that the pen tips rest on an absorbent paper towel or blotter. It will take approximately ten minutes for the water to be drawn out of the pen elements. Any water remaining on the inkwell should be blotted off.

With pen elements in place, carefully remove cover for inspection of inkwell. The inkwell should be thoroughly clean, but if there is any dried ink still in the inkwell or pen elements, it should be removed. When the inking system is cleaned, it may be filled with ink and reinstalled in the recorder.

It is convenient, and sometimes advisable to have an extra pen element to use in the instrument if one is dropped or bent in handling.

DO NOT SPILL INK ON THE RECORDER. Remove any spilled ink immediately, with a rag or blotter. If ink is spilled on clothing, wash it out as soon as possible, preferably with warm water and Lava soap. By persistent washing the spots can usually be removed.

CAUTION: **Always remove pens and inkwell before taking the chart drive out of the recorder, or before subjecting the recorder to any handling which may spill the ink.**

PEN ADJUSTMENT -- If the chart drive has been repaired or moved from one instrument to another, adjustment may be required to make the pens write on their respective lines. This adjustment is made by moving the comb stop to right or left. The comb is held in place by the two screw studs that support the inkwell. Remove the inkwell and pens. Loosen the two studs and pry the comb to the right or left as required. Tighten the studs and replace the

inkwell and pens. If some pens do not write on their respective lines, the pen elements can be bent slightly to align them.

SUPPLIES AND SPARE PARTS

Although the Esterline-Angus factory is prepared to ship charts and ink within two or three days after the order is received, the user should forecast his need for these essential items so that his recorder need never be idle for lack of supplies. Keep on hand at all times enough charts and ink to operate each recorder for at least one month. By purchasing in larger quantities, worthwhile savings can be made on these items.

INK -- Esterline-Angus ink is supplied in two colors, red and green. Both colors are furnished in two-ounce and one pint bottles. Red ink is standard and will be supplied unless otherwise specified.

CHARTS -- Use only E-A charts. We cannot guarantee satisfactory recording unless our charts are used. Record charts should be ordered by number. This number will be found on the right-hand edge of the used chart. A list of available charts is included in the chart catalog section of the Instruction Book.

GUARANTEE

Esterline-Angus instruments are guaranteed to be free from defects due to faulty materials or workmanship. Any instrument proving defective within one year from date of shipment will be repaired or replaced free of charge when returned to our factory, shipping costs prepaid, provided the instrument has not been tampered with or misused. We do not assume responsibility for repairs made outside our factory.

PACKING FOR SHIPMENT

If the recorder is to be returned to the factory for repairs, send a purchase order and ask for shipping instructions and at the same time state clearly the reason for return. If time does not permit this normal handling, the following procedure may be used: Wash out inkwell and pen elements. After replacing emptied inkwell and pen elements, raise pens by means of the pen lifter wire, and tie the wire to the scaleplate. Next, tie scaleplate down to chart drive. This prevents pens from moving during shipment. Remove all studs from switchboard instruments. Protect the glass front with a small board and wrap the recorder in heavy paper to prevent excelsior from sifting into the mechanism.

Use a strong substantial packing box, large enough to permit several inches of dry excelsior on all sides of the recorder. Ship by prepaid express to

THE ESTERLINE-ANGUS CO., INC.,
SPEEDWAY, INDIANA

and mark:

"ELECTRICAL INSTRUMENT, HANDLE CAREFULLY"

THE ESTERLINE-ANGUS COMPANY, INC.

Pioneers in the Manufacture of Graphic Instruments

P. O. BOX 596, INDIANAPOLIS 6, INDIANA

IS 50 1M
NOVEMBER, 1957

PRINTED IN U.S.A.

ESTERLINE-ANGUS

OPERATION (EVENT)

Recorders

Instruments to record

—*When*

A machine is productive or idle
A door is opened
A bank vault is entered
A circuit breaker opened or closed

—*How Long*

A machine is idle
A power outage lasted
A rubber or plastic molding cured
A passenger waited for an elevator

—*How Many*

Telephone calls are made
Bottles are filled by an automatic machine
Articles are made by a screw machine
Vehicles used a highway

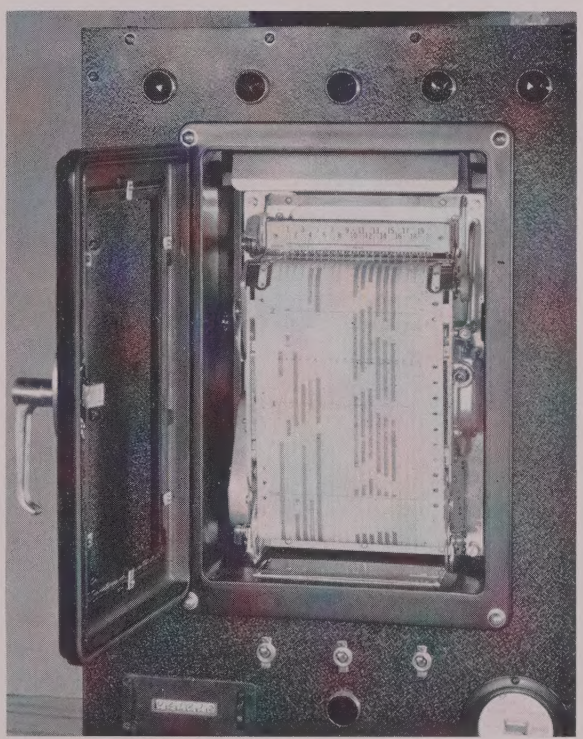


FIG. 1—*The operation recorder gives a set of 20 "yes-no" or "on-off" records as compared to the single quantitative record made by a voltmeter, ammeter or wattmeter. Its charts are rectilinear, making easy the time comparison of the various records*

Model AW Operation (Event) Recorders

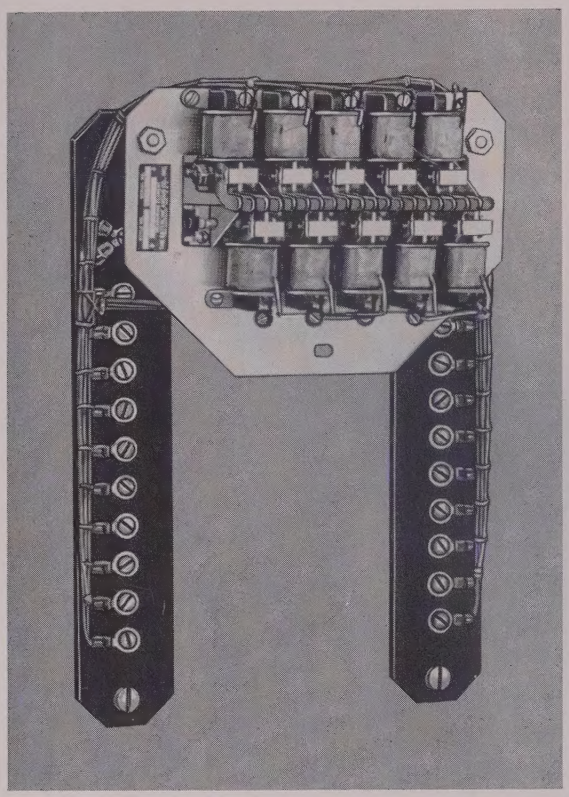


FIG. 2—*The operating element of a 20-pen operation recorder has all 20 electromagnets mounted on a single plate. Completely wired as shown above, it can be installed in and removed from the recorder case without disturbing any internal connections*

THE measuring system or operating element of an operation recorder consists of as many as 20 electromagnets mounted on a single back plate, Fig. 2. Each magnet operates a pen writing on a moving chart. The chart is marked with time of day and is driven by an accurate, rugged chart drive. A large variety of chart drives is available, as described in catalog section 20.

When an electromagnet is energized, the corresponding pen moves 1/10 inch off its normal line and stays there until the magnet is deenergized. Hence, the marks made by each pen show when something happened, how long it lasted, and how frequently the event occurred.

The Writing System

All of the pens are served by a single enclosed inkwell which mechanically supports and aligns the pens. The pen tubes dip into the ink supply through holes in the metal inkwell cover. Short cylindrical counterweights fastened to the pen elements hold the writing pens on the chart paper at all times. These weights project through holes in an extension of the inkwell cover, serving to keep the pen elements in place when the inkwell and pens are removed from the instrument.

Fig. 4 shows a cross section of the writing system and operating linkage. A spacer comb limits the motion of the actuating levers on the electromagnets, so that these levers automatically engage with tapered slots on the rear of the pen arms when the inkwell and pen elements are placed in the recorder. When inserting or removing the chart, all of the pens are lifted out of the way when the scaleplate is tilted back. The inkwell and pen elements appear in Fig. 5.

Types of Recorders

Three types of operation recorders are available:

Voltage type, common return
Voltage type, separate return
Switch type, common return

The type selected depends upon the electrical source and the nature of the application. The following descriptions show the differences between the three types and assist in the selection of the proper one for each application.

Voltage Type

Common Return—The voltage type, common return operation recorder is so named because an external voltage must be available to actuate the electromagnets. The common terminal of the instrument, connected internally to one side of all of the coils, is wired externally to one side of a voltage source (preferably the grounded side). The other terminals of the various coils are wired to the ungrounded terminals of devices on which voltage appears, such as signal lamps, solenoids, or motors. The same voltage which energizes the device being supervised, also actuates the recorder coil connected across the device, as shown in Fig. 19. This type is frequently used to study circuit breaker action, elevator scheduling, timing cycles of automatically controlled processes, and automatic gaging of parts.

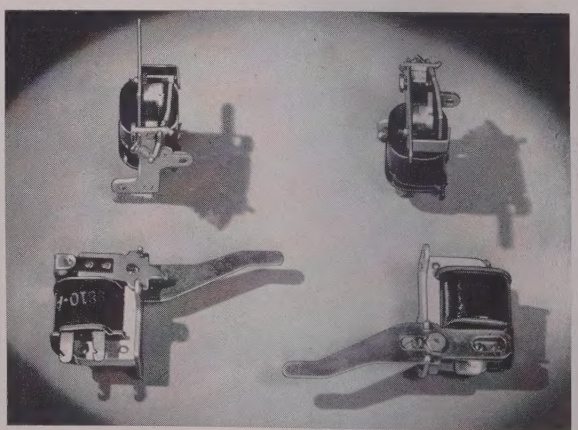


FIG. 3—*Side and top views of typical electromagnet assemblies*

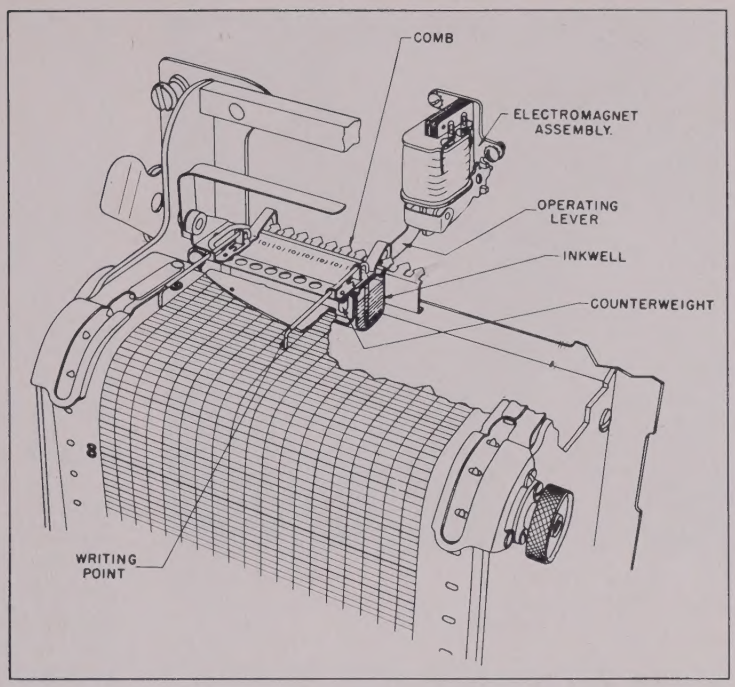


FIG. 4—*Schematic representation of the operating system illustrates the simplicity of the entire mechanism, which contributes to long life and trouble-free service. When the electromagnet is energized, its armature moves and in turn moves the operating lever. Movement of the operating lever is limited by the teeth on the spacer comb. Hence, each pen element moves only this fixed distance in making its record on the moving chart*

Heating, refrigerating and air-conditioning systems, as well as a vast range of chemical processes, can be supervised with this instrument by connecting its electromagnets across the terminals of the solenoid valves or dampers used to control the flow of liquids or gases. Similarly, the running and idle time of pumps, fans, blowers, agitators, grinding mills and all other machines which inherently "produce" whenever they run, can be recorded by connecting the instrument coils across the terminals of the motors driving these machines.

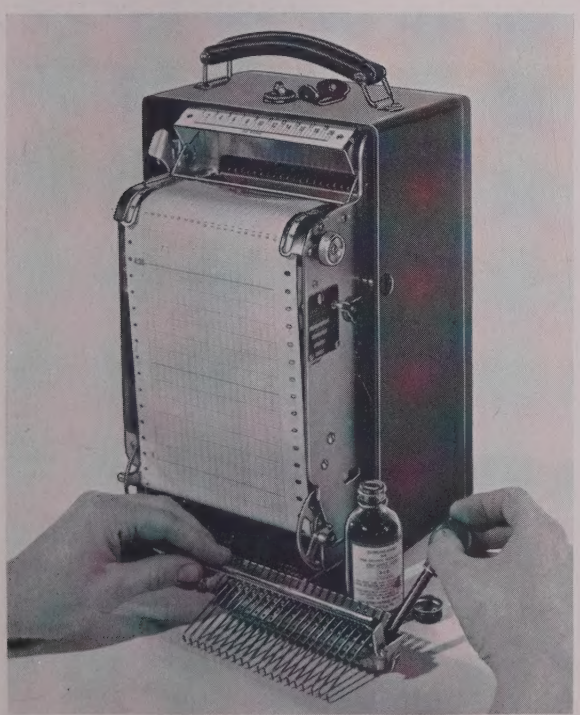


FIG. 5—*All pens are served by a single inkwell which mechanically supports and aligns the pens*

Where the condition to be recorded is mechanical rather than electrical, switches or contactors are used to interrupt an external voltage source and convert the mechanical conditions into electrical impulses which will actuate the recorder. The switch or contactor can be operated from mechanical rotation or thrust, from changing position, or from changes in pressure, temperature or light intensity. Molding time on presses, objects on conveyors, operation of valves, running and idle time of machinery, all may be recorded by this arrangement.

Separate Return—There are applications where the electromagnet circuits must not be interconnected, and for such situations the separate return type of instrument is used. This instrument has a separate pair of terminals for each electromagnet. Typical applications of the separate return type are in load studies in telephone exchanges and in the study of elevator scheduling, where complex systems of wiring and relaying prohibit interconnection between circuits. The use of the separate return on portable instruments eliminates the need for determining polarities and often simplifies installation.

As a safety precaution, the separate return type is often used where connection is made directly across motor terminals. With the common return instrument, one terminal of the motor is always connected through one of the coils in the instrument to the "common" side of the voltage source. Even though

FIG. 6—*Operation recorders can be mounted on the production floor so both operators and supervisory personnel can see the record of productive and idle time*

the motor switch is open, a potential with respect to ground may be present on one of the motor terminals which may constitute a safety hazard. This situation is avoided by the use of the separate return instrument, as illustrated in Fig. 20.

Multiple Voltage Combinations

Voltage type operation recorders can be supplied with several groups of coils wound for different voltages. Multiple voltage combinations are often used in elevator traffic surveys, where different banks of elevators use different signaling voltages, and in plant production checks, where various machines may operate on different potentials. Recorders used in electric generating stations and substations, where two different station battery voltages are present, are furnished with two groups of coils of different ratings and with separate returns as well, to prevent interconnection of existing control circuits.

Recorders with each pen circuit having two or more voltage ratings can also be furnished. The instrument is usually self-contained for the lowest voltage with external circuit resistors for higher voltages. This feature is useful in plant surveys where several voltages exist, and in signaling circuits where more than one potential is encountered.

Switch Type

Where the operation recorder is to be actuated solely by switches or contactors, and where the power supply is AC, the switch type instrument is recommended. This instrument derives its name from the fact that it is restricted to use with switches or contactors. There must be no existing voltage in the circuits to which the recorder electromagnets will be connected.

A small step-down transformer, mounted inside the case, supplies approximately 24 volts AC to actuate the electromagnets. One side of the transformer secondary is connected to one side of all the coils inside the instrument, and the other side of the secondary is brought out to a common terminal on the case. See Fig. 21. The transformer can be furnished with its primary wound for 120 or 240 volts, 50-60 cycles.

Applications of the switch type instrument are the recording of opening or closing of doors, the produc-

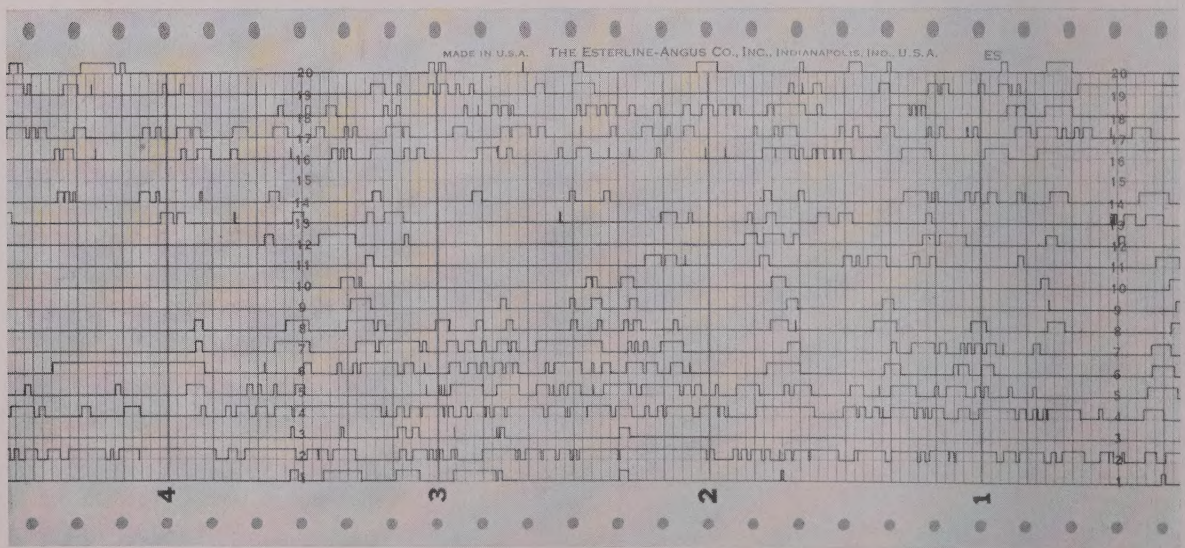


FIG. 7—*Expansion of a plant operating its own dial telephone system made it necessary to add more lines. A 20-pen operation recorder was installed to determine loading on the existing lines. The study continued for several weeks, monitoring 20 lines at a time for a 24-hour day. This typical section of chart shows that line No. 3 had only 8 short calls, while line No. 2 had 59, some of which were quite long. After the study, phones were regrouped so that all lines were more equally loaded. The anticipated number of new lines was reduced*

tive and idle time of screw machines and presses, the passage of objects on a conveyor, the flow of liquid in pipes, and the revolutions of any shaft.

Choice of Types

The selection of the type of instrument depends upon the source of supply of the voltage to operate the electromagnets, and upon the means employed to produce the impulses. The type will depend upon whether the source is AC or DC, and whether or not all pens are to be operated from the same source.

Either the switch type or voltage type of recorder can be used where switches, contacts or relays operate the electromagnets, and where the source is AC. The use of the switch type, however, permits low operating voltages which make possible a reduction in wiring costs, and also eliminates the hazards of higher voltages.

When only DC is available, the voltage type must be used. If the impulses are to be obtained from a switch action, the common return type may be employed. This type may also be connected across voltage-operated devices where a common return is permissible. The voltage type with separate return must be utilized in conjunction with voltage-operated devices where a common return is not permissible. It is also used on complicated relaying systems, or on motors where safety considerations prohibit interconnection.

Total Number of Pens

In deciding on the total number of pens required some thought should be given to possible future growth. After the instrument is in service, it is frequently desired to monitor some additional machines or processes, once the value of these records is apparent. Adding more pens must be done at the factory and it is more expensive than including extra pens when the instrument is built. Taking the recorder out of service and losing valuable records can be avoided by ordering more pens initially.

Where it appears that 6 pens are needed at the time of the initial installation, at least 10 electromagnets should be put in the recorder. Similarly, where 14 or 15 pens are needed, order 20. The writing pens can be left out of the recorder until the corresponding operating coils are put in service.

Methods of Actuating

The simplest method of actuating the electromagnets of the operation recorder is by the direct application of voltage. Signal voltages on elevator systems, voltages across motor terminals, voltages across indicating lamps on circuit breaker systems, voltages across coils of solenoid valves and relays, voltages on railroad interlockers, are all applied directly to the instrument coils without the use of any auxiliary apparatus.

There are some applications where the voltage varies over too wide a range for satisfactory operation of the instrument or where currents are too large to be brought to the instrument. In such instances, appropriate relays should be connected into the circuits to provide the necessary "on-off" impulses. For example, in arc welding, currents of several hundred amperes are encountered, requiring special current relays to operate the recorder. Also, in arc welding, the no-load voltage is several times the working voltage, requiring relays which will respond to the arc voltage without being damaged by the open circuit voltage. See Fig. 17. On some machinery, such as grinders, punch presses and heavy planers, large variations of current occur between no load and full load.

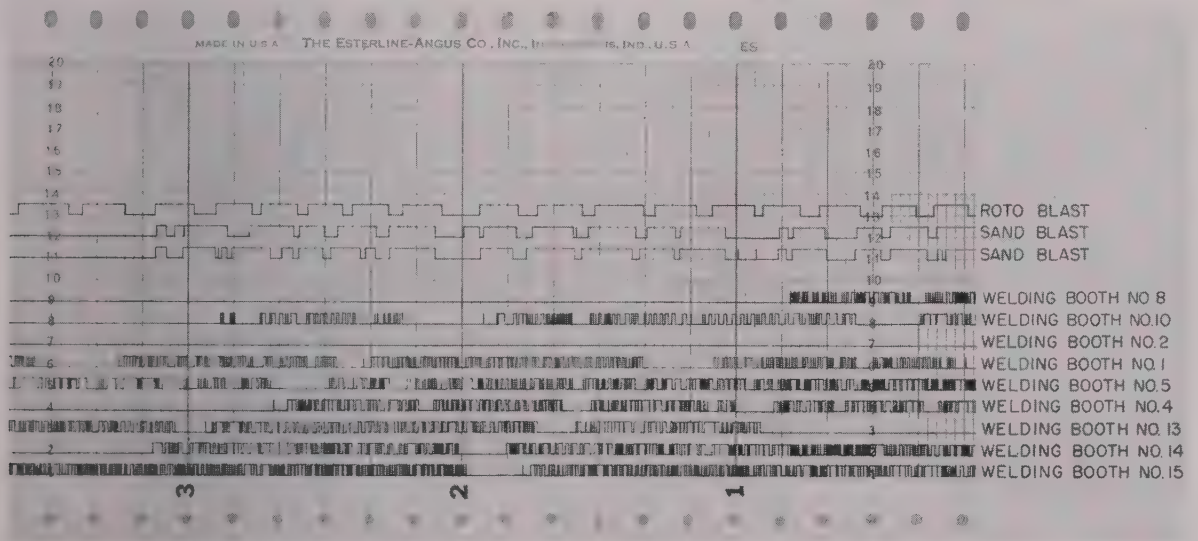


FIG. 8—*Pens 1-9 show the operation of welders in a steel fabricating plant. Pens 11, 12 and 13 show the active and idle time of casting cleaning machines. To provide for the future addition of more production equipment, coils 14-20 are in the instrument but these 7 pen elements will not be used until they are needed. Thus 7 more pieces of equipment can be added to the record at any time*

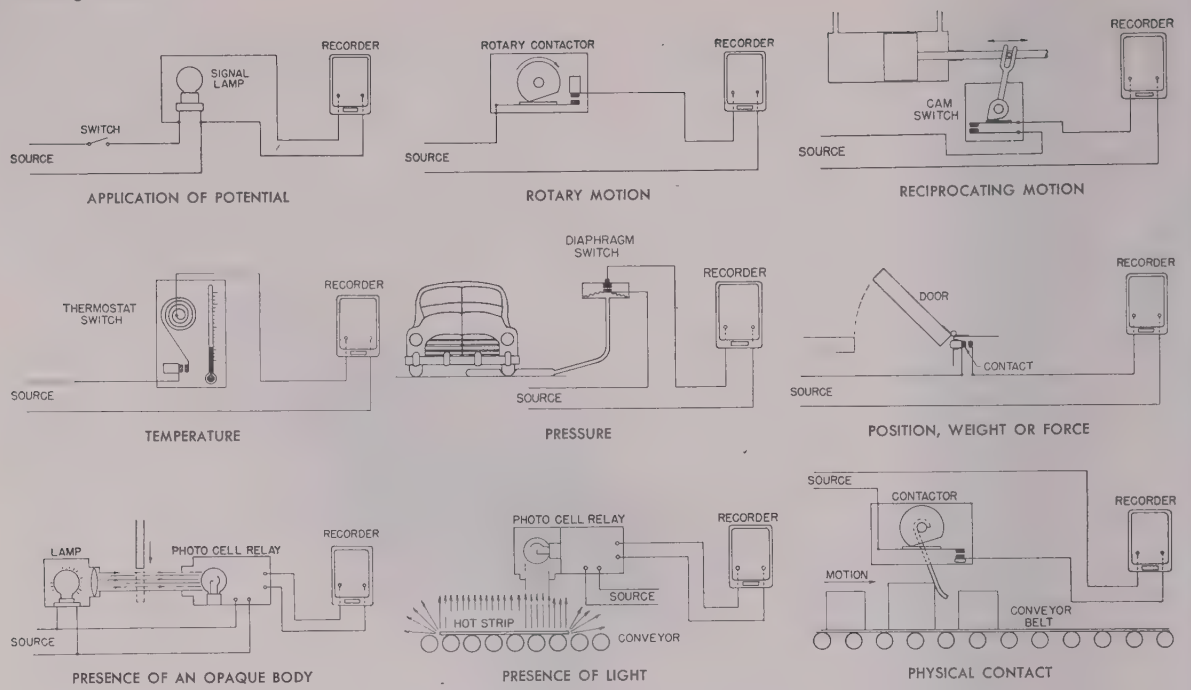


FIG. 9—*These sketches show a few of the variety of ways in which the pens of an operation recorder may be actuated*

Current relays may be installed on these machines to close near full load current and thus cause the instrument to record only the productive time.

The majority of phenomena to be studied are mechanical rather than electrical, and switches or contactors of some sort must be used to convert these phenomena into electrical impulses. In recording the operation of hydraulic presses in plastic molding, rubber vulcanizing, or vegetable oil pressing, a mechanically operated switch is mounted so as to be actuated when the press closes. A similar arrangement is used to record the opening and closing of doors on elevators, bank vaults, cold rooms and mine shafts; to record the position of valves, dampers and gates; and to record the movement and spacing of streetcars, subway trains and trolley buses.

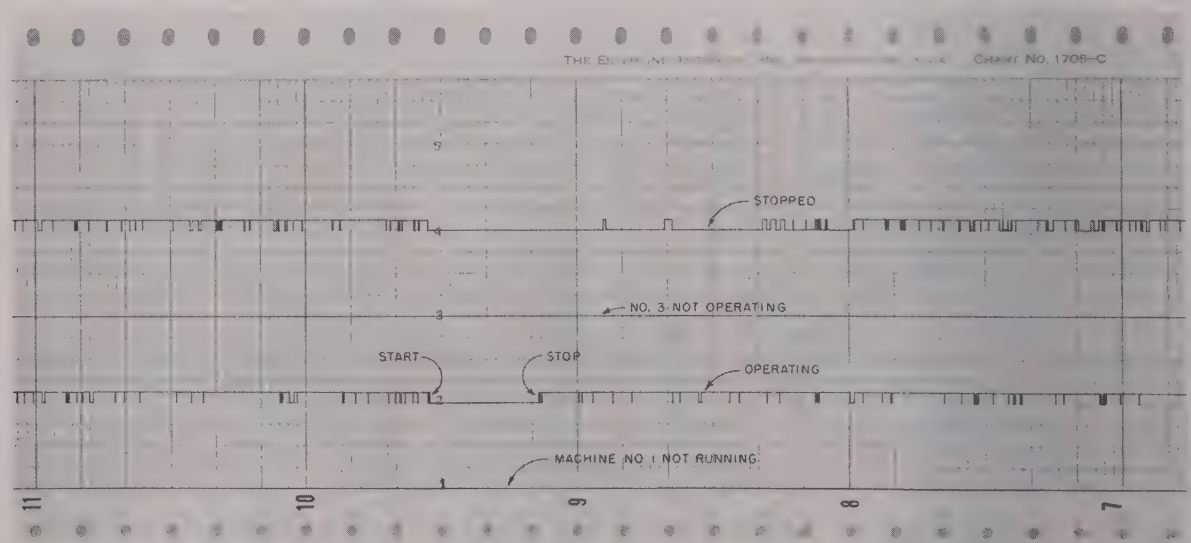


FIG. 10 –*This operation recorder chart was made in a bottling plant with two of the four machines running. Frequent stops of short duration and several shut-downs of 10 to 20 minutes can be seen. Installation of the recorder resulted in substantial reduction of lost time*

*Switches and Contactors**

Suitable switches, intended for actuation by physical movement, may be obtained from the Micro-Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.; Production Instrument Co., Chicago; Veeder-Root, Inc., Hartford, Conn.; and Mu-Switch Div. Acro Mfg. Co., Columbus, Ohio. Limit switches are available from Cutler-Hammer, Inc., Milwaukee; General Electric Co., and Westinghouse Electric Corp.

Heavy duty rotary cam switches, made by Veeder-Root, Inc., are designed for direct connection to rotating shafts. Each rotation of the shaft produces one electrical impulse. This same switch, fitted with a projecting lever arm, may be connected to reciprocating machinery.

Switches with extended levers may be used to count passage of objects on a conveyor and in some cases to record movement of billets, castings and tools to and from heating furnaces. These switches are mounted so that the extended lever will be actuated by the passing objects. The Production Instrument Co., Chicago, supplies this type of switch.

There are many counting applications where a mechanical device is not satisfactory. Objects may be too irregular in shape to insure moving a switch lever, they may be inaccessible, as in a chute, or they may be too delicate to move a lever, as in the case of cloth or paper. By placing a light source and an electric eye on opposite sides of the conveyor belt and just above the surface, all objects regardless of shape or size, will interrupt the beam and be counted. A few of the companies making photoelectric relays are: General Electric Co.; Photoswitch Div., Electronic Corp. of America, Cambridge, Mass.; The Ripley Co., Middletown, Conn.; Westinghouse Electric Corp., and Weston Electrical Instrument Corp., Newark, N. J.

*The list of manufacturers in the following paragraphs is not intended to be complete. Only a few are mentioned to be of assistance in applying operation recorders.

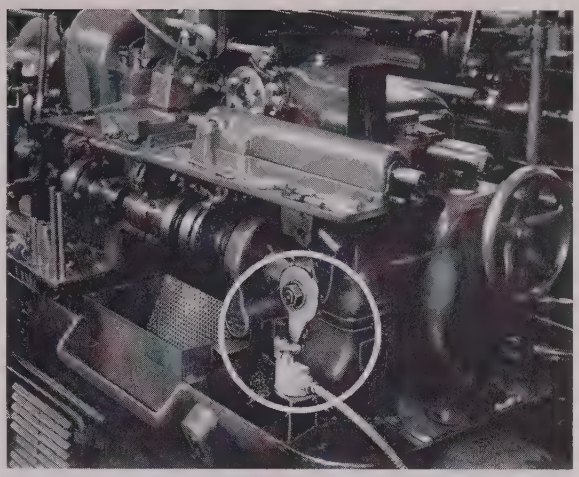


FIG. 12—*A switch operated by the over-arm cam of a screw machine will actuate its pen on the operation recorder only when work is being done*

Since the photo-electric cell responds to the presence of light, it may be used to indicate the opening of furnace doors, movement of glowing billets, presence of flame in a furnace, or light in a room. The "Vis-a-Flame" tube, made by Minneapolis-Honeywell Regulator Company, is responsive to radiant heat and may be used to record movement of hot castings, billets, furnace doors, glass pots, etc.

Switches are available which will close electrical contacts when a desired pressure or vacuum exists. Pressure-operated switches may be connected to presses to indicate their production, to water mains to indicate pressure, or to tanks to show filling and

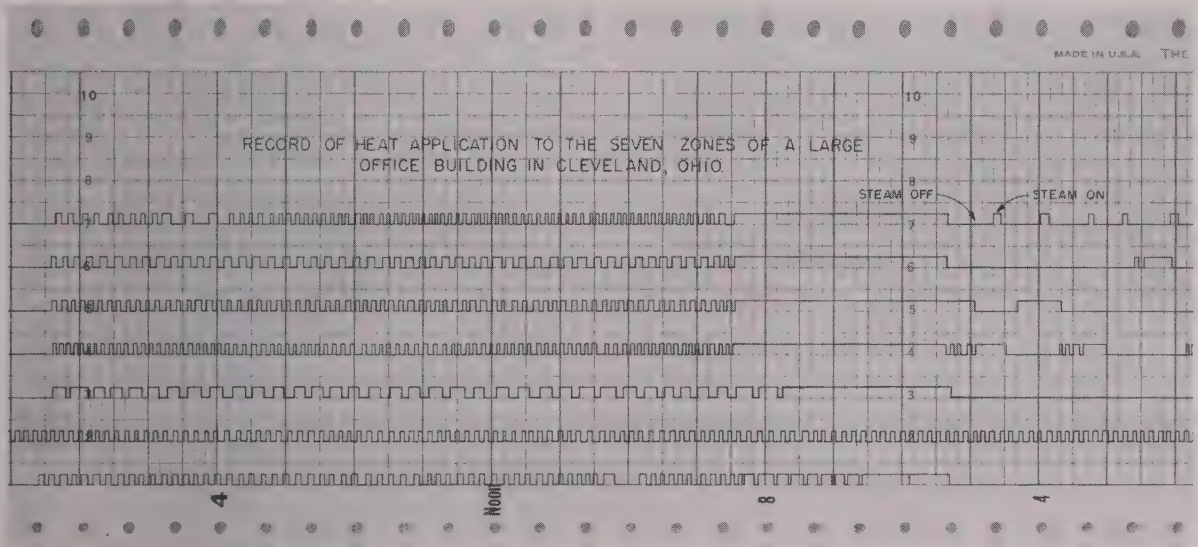


FIG. 11—*The action record of seven valves controlling the heating in different zones of a large Cleveland office building is shown in this record. Note that zone 2 was heated continuously but the other 6 zones were heated only during working hours. Service personnel will follow instructions when their actions are recorded*

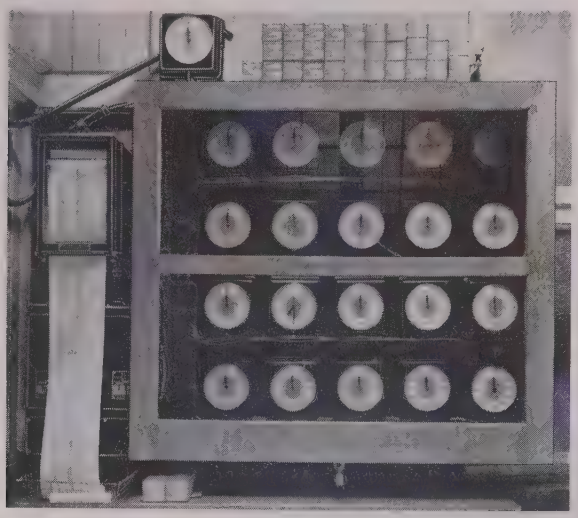


FIG. 13—*While the operation recorder shows productive and idle time of a group of arc welders, 20 clocks totalize the actual welding time for each operator*

emptying. Pressure and vacuum switches are particularly applicable to recording the operation of heating, refrigeration, and air-conditioning systems. The Minneapolis-Honeywell Regulator Co., Mercoid Corp., Chicago, Cook Electric Co., Chicago, and Barksdale Valves, Los Angeles, Calif., manufacture such switches.

The Mercoid Corp. also makes a float-operated switch for recording liquid levels. The Autocall Co., Shelby, Ohio, manufactures a flow indicator which closes its contacts when there is a flow of liquid through a pipe, as in automatic sprinkler systems. Thermostats and thermal relays, to indicate when certain temperatures are attained in liquids or in free space, are made by Fenwal, Inc., Ashland, Mass.; Thomas A. Edison, Inc., West Orange, N. J.; and Minneapolis-Honeywell Regulator Co.

Avoiding Misleading Records

In all applications of the operation recorder, it is essential that the instrument respond only when the desired action, usually actual production, takes place. This may involve the fulfilling of two or more conditions simultaneously. In such cases, two or more switches are used in series, the pen-actuating electromagnet being energized only when both switches are closed. For instance, a screw machine may continue its cycle of operations although it has run out of stock. To eliminate false recording, two contactors are used in series. One is connected to the cam shaft, while the other is mounted so as to be closed by the piece of stock being machined.

On textile looms, on rotary presses in newspaper plants, or on cable machines, many shafts will be rotating even when there is no production. To prevent false records, cam switches may be attached to idler rolls, so that the impulses will be sent to the recorder only when stock is actually moving through the machine or press, causing the idler to rotate.

In arc welding, useful deposition of metal takes place only when there is current flowing and when, at the same time, there is voltage across the arc. If the arc is broken while the welding generator is running, there will be voltage, but no current. If the electrode is short-circuited against the work, there will be current, but no voltage. To insure that the

Rectangular Pattern

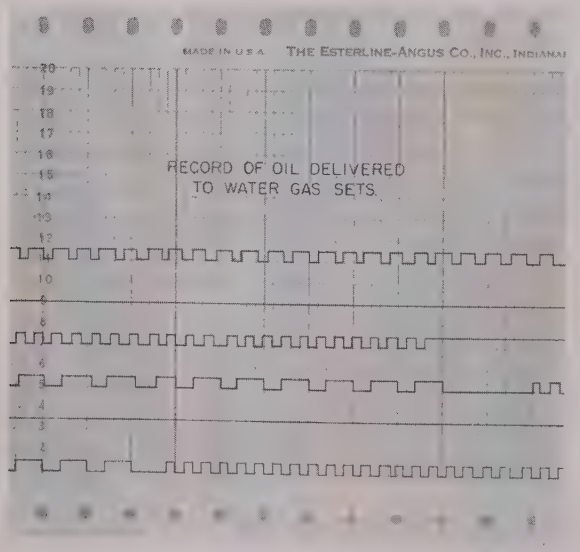


FIG. 14—*By placing contacts on the dials of oil meters, an operation recorder shows the rate at which oil is delivered to 6 water gas sets*

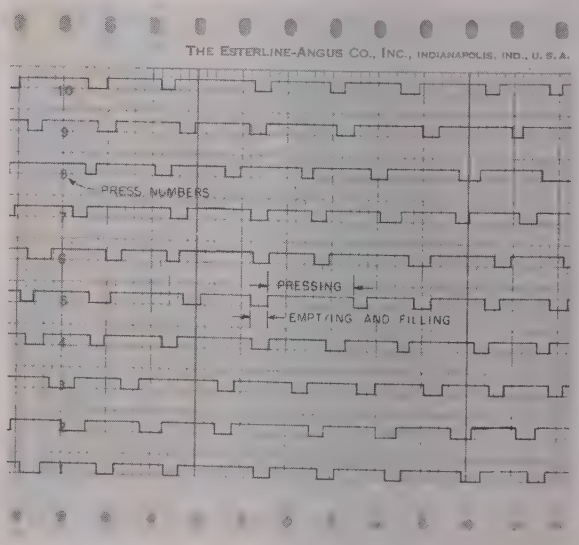


FIG. 15—*This record shows the operation of 10 cotton-seed oil presses. The recorder pens are energized by a pressure switch on each press*

Band Pattern

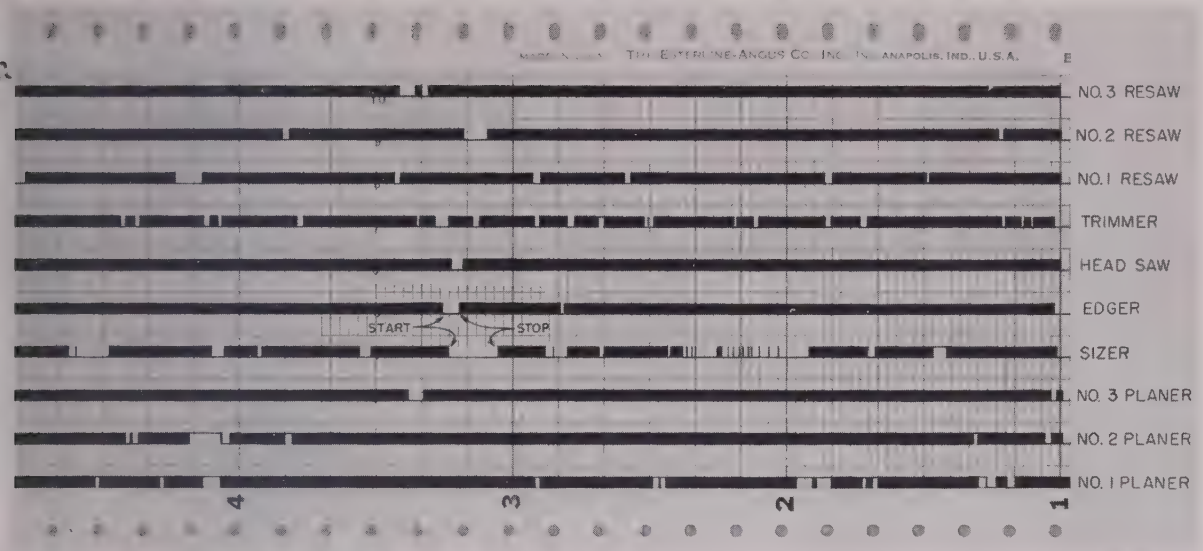


FIG. 16—*The operation of 10 machines in a lumber mill is shown above. The relatively few idle periods are the result of considerable effort on the part of the superintendent and operating people. Such good records can be obtained only by having the operators write down the reason for each delay. Then it is up to management to remove or minimize those causes*

instrument is energized only during useful welding, two relays are used, one responsive to arc current, and the other responsive to arc voltage. The contacts of the two relays are wired in series, so the pen electromagnet is energized only when both relays are simultaneously closed. This method of wiring is shown in Fig. 17.

Counting and Totalizing

In many installations of the operation recorder, it is desirable to add up total time. For example, on an electric arc welding circuit it is advantageous to know for each working day how many hours of actual welding have been accomplished. By connecting a self-starting synchronous clock in parallel with each electromagnet of the voltage type operation recorder, the clock will run only when the electromagnet is energized, and will thus totalize the useful welding time. See Fig. 13. Time totalizers or hour counters, fitted with direct reading dials, are supplied by the General Electric Co.; Sangamo Electric Co., Springfield, Ill.; Weston Electrical Instrument Corp.; and Westinghouse Electric Corp.

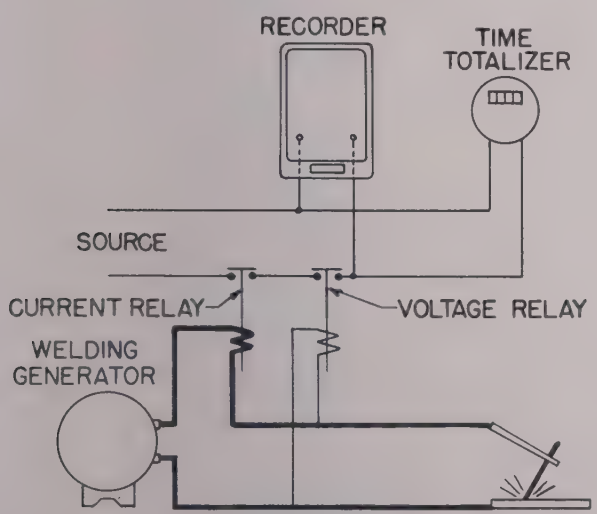


FIG. 17—*Use of both current and voltage relays to energize a pen circuit insures operation of the pen only when welding is actually being done*

Frequently it is valuable to know the total number of operations within a given time. Such totals can be obtained by connecting a counter in parallel with each electromagnet of the voltage type recorder. Counters of this type are made by Veeder-Root, Inc. and Production Instrument Co. They can be furnished for operation on 24 or 120 volts DC, and 24, 120 or 240 volts AC, 50-60 cycles.

Hour counters and totalizers can be used only with the voltage type instrument, since the internal transformer in the switch types does not have enough capacity to operate external devices.

Types of Records

Three different types of record patterns may be obtained on the chart, depending upon the relation of the length of time the pen is energized, the time the pen is de-energized, and the chart speed. These types are the rectangle, band, and impulse patterns, so-called because of their appearance on the chart.

Rectangle Pattern—This is the most common type of record. The electromagnet is energized only when some event or condition occurs, the time of energizing being long enough for the pen to produce an open rectangle on the chart. When the condition does not

Impulse Pattern

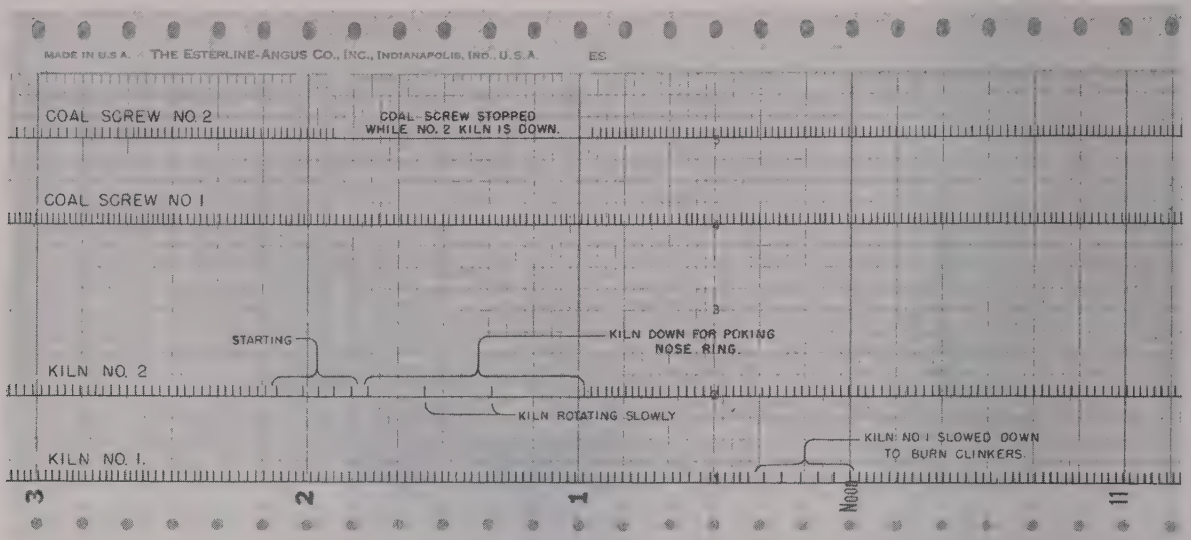

MADE IN U.S.A. THE ESTERLINE-ANGUS CO., INC., INDIANAPOLIS, IND., U.S.A.
COAL SCREW NO. 2
COAL SCREW STOPPED WHILE NO. 2 KILN IS DOWN.
COAL SCREW NO. 1
STARTING
KILN DOWN FOR POKING NOSE RING.
KILN NO. 2
KILN ROTATING SLOWLY
KILN NO. 1 SLOWED DOWN TO BURN CLINKERS.
KILN NO. 1.
NOON
11

FIG. 18—*This record shows 4 pens being used to chart operation of 2 cement kilns, and the coal screws feeding them. Movements of the coal screw pens indicate every hundredth revolution. Pens on the kilns show each revolution. The chart shows that Kiln No. 2 was slowed down at 1 P.M. to poke a nose ring. It continued revolving one revolution every twenty minutes to prevent warping. Coal screw No. 2 stopped entirely while its corresponding kiln was down. The chart also shows that Kiln No. 1 was slowed down at noon, in this case to burn clinkers. In order to gain more efficiency from a cement kiln, the stops are observed by the superintendent and the causes analyzed*

exist, the electromagnet is de-energized. Although the chart speed is not critical, speeds should be used which are no higher than necessary to obtain the required accuracy in time measurement. Typical records of this type are illustrated in Figs. 14 and 15.

When pressure is applied to a curing press, Fig. 15, the corresponding recorder pen is energized by the contacts of a pressure-operated switch in the hydraulic line. The pen remains in the "on" position as long as the pressure is maintained. Each rectangle shows the duration of one operation. Other applications which produce the rectangle pattern are the recording of the passage of trains through railroad interlockers, checking circuit breaker operation, studying elevator movements, and supervising many chemical processes.

Band Pattern—The band type record is produced when an operation recorder pen is actuated by a rapidly closing and opening contactor. This contactor is usually one which is connected to reciprocating or rotating machinery so as to open and close with each stroke or revolution. Chart speed and method of actuation are chosen so that the cycle occurs with enough rapidity in comparison to the chart travel to cause the pen to produce overlapping marks. The resulting bold band, produced during machine activity, contrasts sharply with the single line drawn when the machine is not running. Fig. 16 shows a band record of productive time on ten machines in a lumber mill. This style of record is also obtained when the operation recorder checks the working and idle time of automatic screw machines making small parts, cable braiding machines, etc. There should be not less than 80 strokes and not more than 200 strokes of the pen per inch of chart travel in the band pattern.

Impulse Pattern—This type of record is produced when the pen is energized only momentarily. The return stroke of the pen falls on practically the same path as the active stroke, so that the pen draws a single crosswise mark. As the chart moves ahead, other marks, with spacing in between, are produced by similar actions. The number of these marks per given time, and the spacing between them, may be accurately determined. Fig. 18 is an example of this type of presentation, showing revolution counting of

Continued on page 12

TABLE I—STANDARD CHART SPEEDS, TIME VALUES AND RUNNING TIMES

Chart Speed	Spacing of Minor Divisions	Time Value per Minor Division	Time One Chart Will Last
3/4 inches per hour	1/8 inch	10 minutes	65-2/3 days
1-1/2inches per hour	1/8 inch	5 minutes	32-1/3 days
3 inches per hour	1/10 inch	2 minutes	15-2/3 days
6 inches per hour	1/10 inch	1 minute	7-1/3 days
12 inches per hour	1/10 inch	1/2 minute	3-2/3 days
3/4 inches per minute	1/8 inch	10 seconds	26-2/3 hours
1-1/2 inches per minute	1/8 inch	5 seconds	13-1/3 hours
3 inches per minute	1/10 inch	2 seconds	6-2/3 hours
6 inches per minute	1/10 inch	1 second	3-1/3 hours
12 inches per minute	1/10 inch	1/2 second	1-2/3 hours
3/4 inches per second	1/8 inch	1/6 second	26-2/3 minutes
1-1/2 inches per second	1/8 inch	1/12 second	13-1/3 minutes
3 inches per second	1/10 inch	1/30 second	6-2/3 minutes

NOTE: Special change gears are available for chart speeds of one inch per minute and per second. When using these speeds and a chart with 1/10 inch spacing of the minor divisions, each minor division equals 1/10 minute or 1/10 second, respectively. Such speeds are useful in time studies.

Model AW Operation (Event) Recorders

All recorders are guaranteed to operate at voltages 15% above or below rating

VOLTAGE TYPE—Specify Common or Separate Return

Rated Voltage	Coil Style	Milli-amperes	Watts per Circuit	Ohms per Coil (DC)	Ohms in Series With Coil
Direct Current					
2 Volts	N	510	1.0	3.9	None
4 Volts	K	250	1.0	15.8	None
6 Volts	J	210	1.3	28.5	None
8 Volts	G	120	1.0	68	None
10 Volts	F	93	0.9	108	None
12 Volts	F	110	1.3	108	None
14 Volts	E	83	1.2	168	None
16 Volts	D	62	1.0	257	None
18 Volts	D	70	1.3	257	None
24 Volts	C	60	1.4	400	None
28 Volts	B	40	1.1	680	None
32 Volts	A	28	0.9	1150	None
48 Volts	T	28	1.4	1700	None
125 Volts	T	26	3.3	1700	3000
250 Volts	T	26	6.5	1700	8000
25 Cycles AC					
6 Volts	L	380	1.7	9.7	None
12 Volts	H	160	1.4	43	None
24 Volts	E	81	1.4	168	None
120 Volts	T	27	2.7	1700	1500
240 Volts	T	27	6.3	1700	7000
50-60 Cycles AC					
6 Volts	N	470	1.5	3.9	None
12 Volts	K	230	1.5	15.8	None
24 Volts	G	100	1.3	68	None
120 Volts	T	20	1.3	1700	None
240 Volts	T	21	4.3	1700	7000

SWITCH TYPE, Common Return Only

50-60 Cycles AC		Electrical characteristics of individual coils are same as listed for voltage type,
120 Volts	G	24 volt, 50-60 cycle, style G coil, in above
240 Volts	G	table.

Charts—Rectilinear. 1700 series. See chart list 355 or catalog section 90.
Use chart 1705 for recorder with 1 to 5 pens.
Use chart 1710 for recorder with 6 to 10 pens.
Use chart 1720 for recorder with 11 to 20 pens.
Use chart 1740 for right-hand side of twin recorder having 20 pens in the left-hand side.

Scales—To match number of pens.

Leads—Furnished only on twin wall type recorders and on single wall recorders having more than 10 pens. Length approximately 4 feet. Leads used with switch type recorder may have resistance up to 35 ohms per circuit (approximately 5000 feet of No. 18 wire, 2500 feet one way).

Binding Posts—Furnished on portable recorders.

Multipliers—None required for recorders rated 120 volts, 50-60 cycles; 80 volts, 25 cycles; 48 volts DC. Higher voltage recorders may use one or two separate multipliers, depending on rating and number of pens.

Response Speed—For pens to make full deflection, circuit must be closed or open for at least 1/20 second, allowing a maximum of 10 cycles per second with equal "on" and "off" periods.

Chart Speed—Charts should be run fast enough to give the desired timing accuracy, yet not so fast as to cause excessive paper consumption and laborious inspection. To count the individual strokes of each pen, the chart speed should be selected so that there are not more than 30 strokes per inch of chart travel. When using the band type record, speed should be such that there are not less than 80 strokes nor more than about 200 strokes per inch of chart travel. (See Table I, page 10.)

Pen Location—Pens will be located in standard positions designated on charts 1705, 1710 and 1720, unless otherwise specified.

Future Pens—See page 5.

Dielectric Test—2000 volts, 60 cycles, for one minute.

Intermediate and Special Ratings—Voltage type recorders can be furnished for any voltage from 2 to 250 volts DC; 5 to 240 volts, 50-60 cycles; and 3.5 to 240 volts, 25 cycles. For series operation, such as in the secondary of a current transformer, special low impedance coils should be used. Consult factory, giving details of application. Switch type recorders are available only in the ratings shown in the table.

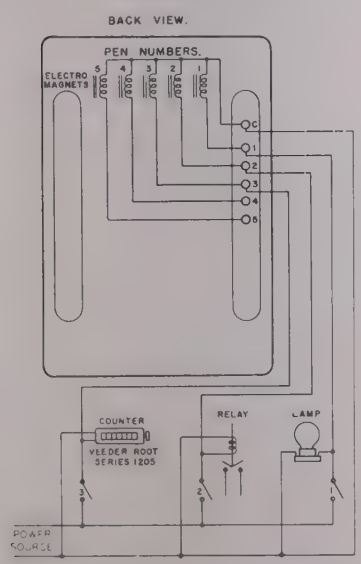


FIG. 19—*Wiring diagram of voltage type, common return recorder actuated by line voltage across signal lamps, relays or counters*

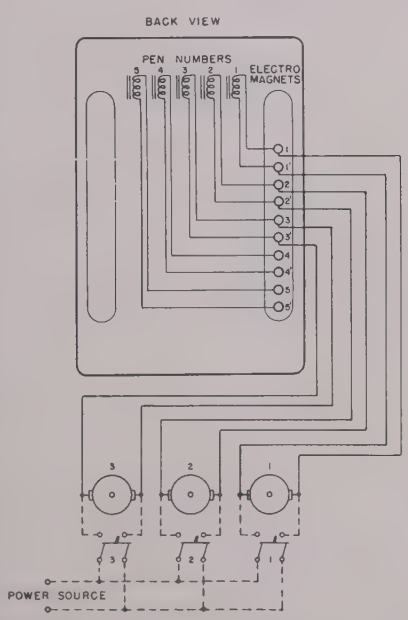


FIG. 20—*Wiring diagram of voltage type, separate return recorder. Separate return circuits are available only on voltage type recorders*

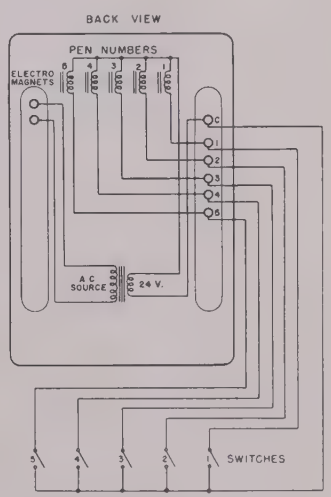


FIG. 21—*Wiring diagram of switch type operation recorder. This instrument is furnished only with common return pen circuits*

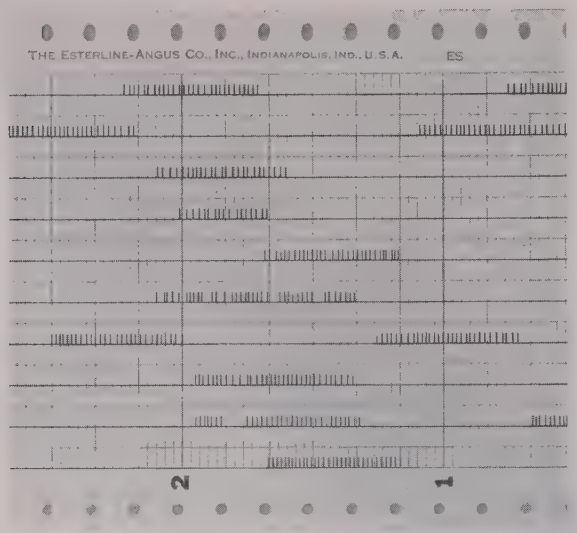


FIG. 22—*Each mark of a pen shows the withdrawal of a billet from one of 10 heating furnaces. Heating time and rate of withdrawal can be taken from the record*

Continued from page 10

slow moving devices. When it is desired to count individual operations, there should be not more than 30 strokes of the pen per inch of chart.

The impulse record is also obtained when counting objects on a conveyor belt, billets from a heating furnace, or vehicles on a highway. This type of pattern usually results when the recorder is used to gather time study data. The observer is supplied with several push buttons which actuate various pens of the recorder. When a machine operator or an assembler performs a certain operation, the observer presses the proper button, thus producing a mark on the chart. Time studies are then made from the record thus produced.

Combination Pattern—It is sometimes desired to make one pen produce more than one type of record to indicate different conditions. For example, operation recorder pens showing train operation in Chicago's subway system, indicate when a signal to start has been given. This is the start of the rectangle pattern. The end is when the train actually starts. When the length of this pattern exceeds a predetermined time, the pen is caused to vibrate and paint a band. Hence, overtime standing in any station is apparent at a glance.

Similarly, an elevator causes the pen to draw a rectangle pattern. A rectangle is drawn while standing at the top as well as at the main floor. To distinguish between the two, the pen circuit can be interrupted to paint a band while the elevator is standing at the top floor. Then, direction of travel is always obvious by simply noting what type of pattern started the portion of record being examined.

Cases

Portable, wall, flush and front switchboard single cases are available and all but portable are also furnished in twin mounting. Flush cases have 120 volt, 60 cycle, fluorescent lighting. For certain other power sources, incandescent lighting can be furnished.

Chart Drives

Briefly, chart drives are divided into three general classes: hand-wound spring, motor-wound spring and synchronous. Each type can provide chart speeds of ¾, 1½, 3, 6 and 12 inches per hour and per minute. Higher chart speeds of ¾, 1½ and 3 inches per second are obtained with external motor attachments.

How to Order—*Specify*

1—Case Style (Catalog Section 15): Portable, Flush Switchboard, Front Switchboard, Wall Mounting.

2—Chart Drive (Catalog Section 20): Hand-wound Spring, Motor-wound Spring, Synchronous. If electric give voltage and frequency. If electric hour-to-minute shift desired, give voltage and frequency.

3—Operating Element: Voltage type, common return; Voltage type, separate return; Switch Type. Voltage, Frequency, Number of Electromagnets, Number of pens.

4—Chart (Catalog Section 90): Chart number, Chart speed.

5—Accessories and Attachments (Catalog Section 80): Writing door, glass corner in case cover, chart inspector, carrying case, electric counters.

6—Supplies (Catalog Section 90): Charts, extra pen elements, pen points, ink.

THE ESTERLINE-ANGUS COMPANY, INC.

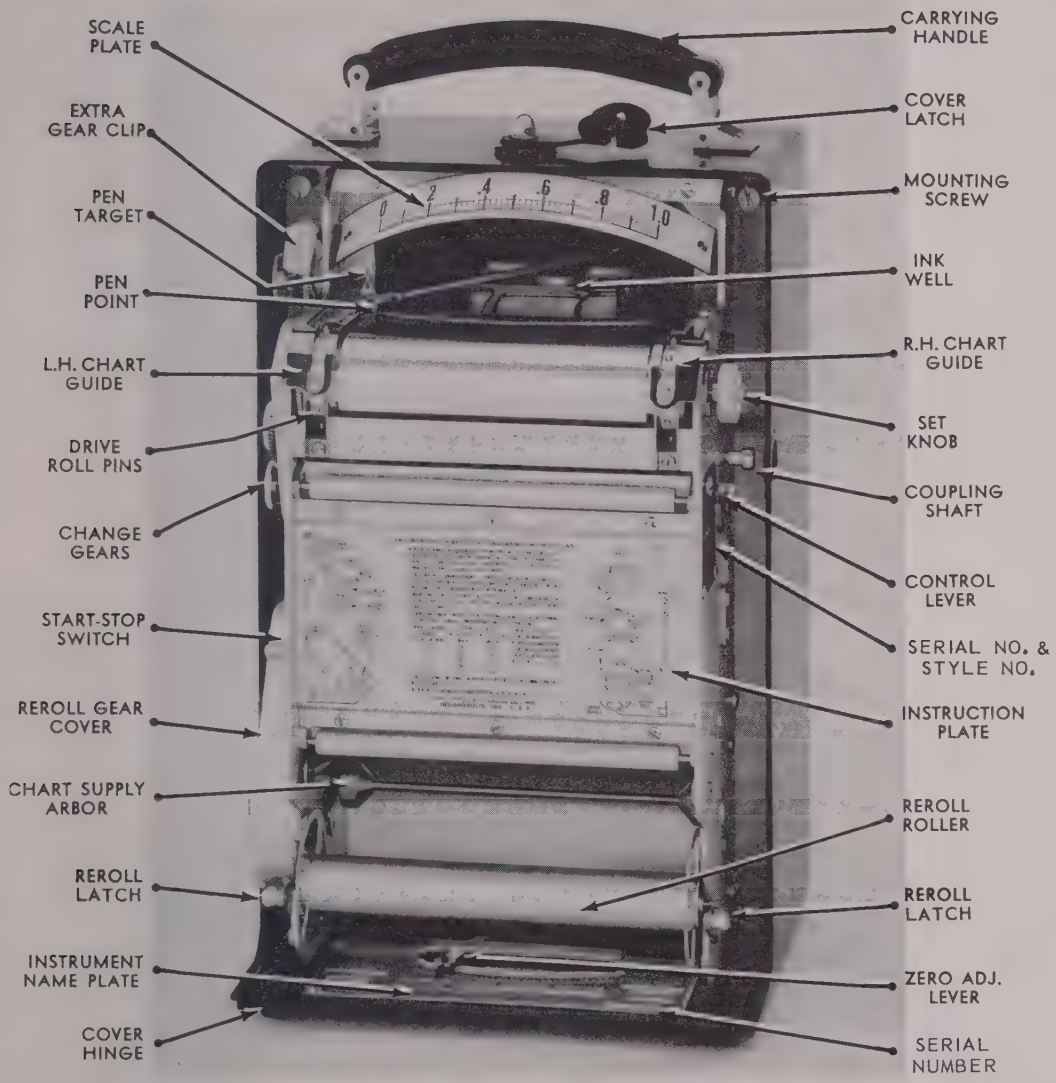
Pioneers in the Manufacture of Graphic Instruments

P. O. BOX 596, INDIANAPOLIS 6, INDIANA

Catalog Section 50
Printed in U.S.A., 7.5M

Product Representatives
in Most Principal Cities

INSTRUCTIONS
FOR THE OPERATION AND CARE OF
ESTERLINE-ANGUS CHART DRIVES



Principal parts of a recorder with synchronous drive are shown above. General information applying to all drives appears on pages 2 and 3, followed by specific instructions for each type of drive.

TABLE OF CONTENTS

	Page		Page
General	2	Selsyn	7
Lubrication	3	Special	8
Synchronous	3	External Motors	8
Spring	4-6	Putting a Meter in Service	10-12
Phantom	7		

When corresponding about a chart drive or in ordering parts, always give the serial number of the recorder and the chart drive style number.

Esterline-Angus Chart Drives are made for the sole purpose of feeding the record chart at various speeds. The instruction plate on the front of all standard power drives shows the path traveled by the chart, change gears to use for each standard speed, and how to start and stop the drive. Change gears for special speeds, if any, are stored on a clip at the upper right corner of the drive. In changing gears, the keyway in the hub must engage the key on the shaft and the knurled nut holding each gear must be tight. DO NOT PRY GEARS OFF THE SHAFTS. A straight pull will avoid bending a shaft.

Electric Shift - Drives equipped with an electric shift to change chart speeds automatically from inches per hour to inches per minute have a separate pair of terminals on the back of the meter. Voltage and frequency of the electric shift may not be the same as that of the motors. Note the terminal markings and the connection diagram before connecting power to these terminals.

Coupling Drives - Every chart drive, except the Selsyn, has a shaft for coupling to an external source or to the phantom drive in a twin meter. It is not desirable to couple two synchronous drives. If set to the same time and operated from the same source, they will stay synchronized. Motor-wound spring drives should not be coupled to each other but may be coupled to a phantom drive in a twin meter or to an external driving source.

Two hand-wound spring drives can be coupled to synchronize chart timing. The drives must be in good condition and timed accurately, or they may stop. Coupled drives will operate at both hour and minute feeds.

Couplings - A phantom coupling is suitable for coupling the power chart drive in a twin instrument to the phantom chart drive. It is made to spring over the coupling ball fittings and eliminate any lost motion or backlash between the two drives. It is not suitable for transmitting heavy torque and it does not take the place of the power couplings, such as those used for external motor drive devices. Excessive torque on a phantom coupling will damage it.

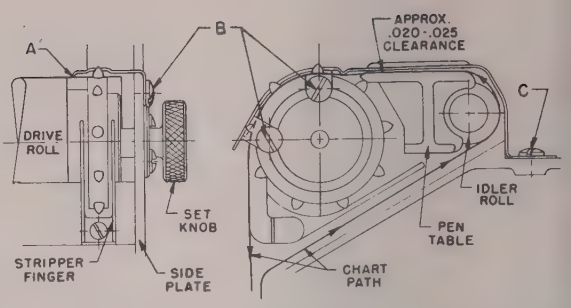


Fig. 3 — Chart guides are properly adjusted at the factory and require change only if repair work is done. Instructions for readjustment are contained in the accompanying text.

Removing Chart Drives From Twin Cases - Before attempting to remove a chart drive from a twin case the coupling must be disconnected by pushing the coupling endwise as far as it will go. If it is pushed to the right, the left-hand chart drive can be removed. Do not pull the drive out at an angle to disconnect from the coupling. This may damage the chart drive and the coupling. A phantom coupling, when properly located, should extend about the same amount over each coupling ball fitting.

Adjusting Chart Guides - The chart guides are properly adjusted at the factory and the adjustment should not be changed. If the drive has been subjected to rough handling or been disassembled, readjustment will be necessary.

The correct position of the chart guides is evident when there is no tendency of the paper to be depressed into the grooves on the drive roll. The

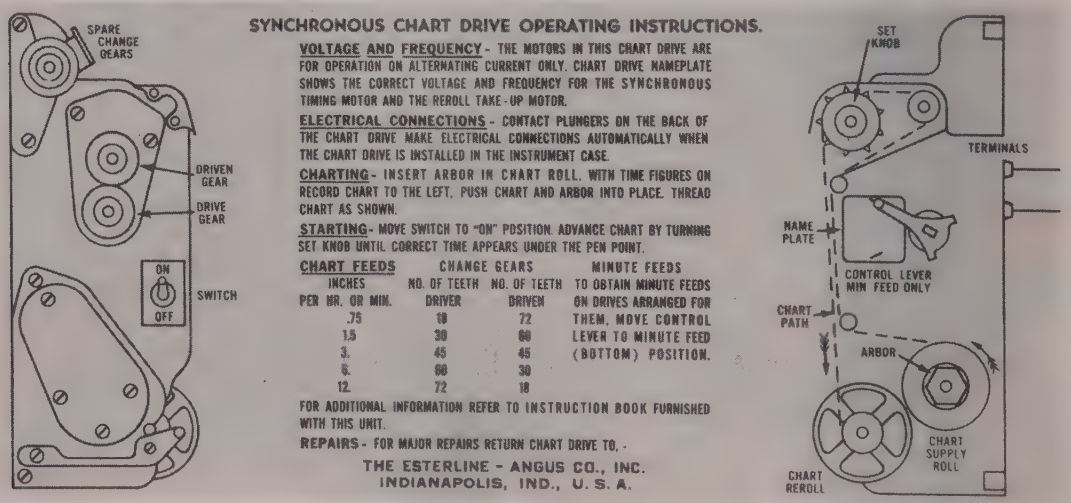

SPARE CHANGE GEARS
DRIVEN GEAR
DRIVE GEAR
ON
OFF
SWITCH
SYNCHRONOUS CHART DRIVE OPERATING INSTRUCTIONS.
VOLTAGE AND FREQUENCY - THE MOTORS IN THIS CHART DRIVE ARE FOR OPERATION ON ALTERNATING CURRENT ONLY. CHART DRIVE NAMEPLATE SHOWS THE CORRECT VOLTAGE AND FREQUENCY FOR THE SYNCHRONOUS TIMING MOTOR AND THE REROLL TAKE-UP MOTOR.
ELECTRICAL CONNECTIONS - CONTACT PLUNGERS ON THE BACK OF THE CHART DRIVE MAKE ELECTRICAL CONNECTIONS AUTOMATICALLY WHEN THE CHART DRIVE IS INSTALLED IN THE INSTRUMENT CASE.
CHARTING - INSERT ARBOR IN CHART ROLL. WITH TIME FIGURES ON RECORD CHART TO THE LEFT, PUSH CHART AND ARBOR INTO PLACE. THREAD CHART AS SHOWN.
STARTING - MOVE SWITCH TO "ON" POSITION. ADVANCE CHART BY TURNING SET KNOB UNTIL CORRECT TIME APPEARS UNDER THE PEN POINT.
CHART FEEDS
INCHES PER HR. OR MIN.
CHANGE GEARS
NO. OF TEETH DRIVER
NO. OF TEETH DRIVEN
MINUTE FEEDS
TO OBTAIN MINUTE FEEDS ON DRIVES ARRANGED FOR THEM, MOVE CONTROL LEVER TO MINUTE FEED (BOTTOM) POSITION.
.75 18 72
1.5 30 60
3. 45 45
6. 60 30
12. 72 18
FOR ADDITIONAL INFORMATION REFER TO INSTRUCTION BOOK FURNISHED WITH THIS UNIT.
REPAIRS - FOR MAJOR REPAIRS RETURN CHART DRIVE TO, -
THE ESTERLINE - ANGUS CO., INC.
INDIANAPOLIS, IND., U. S. A.
SET KNOB
TERMINALS
NAME PLATE
CONTROL LEVER MIN FEED ONLY
CHART PATH
ARBOR
CHART SUPPLY ROLL
CHART REROLL

Fig. 2 — The synchronous chart drive is controlled by a single switch. Location of the switch, charting up and selecting change gears are explained briefly on the instruction plate above.

turned down edge "A" Fig. 3, should follow the contour of the drive roll but allow clearance for the chart paper, so that there is no drag on the paper. It may be necessary to loosen screws "B" (2 per guide) in order to facilitate this adjustment. Screw "C" may also be loosened when necessary to provide parallel clearance over the pen table and proper parallel positioning of chart guides with relation to the side plate.

Cleaning, Lubrication and Repair - The chart drive can be removed for cleaning and oiling by loosening the four corner mounting screws. The drive can then be pulled forward out of the case. Connections to any electrical features will be disconnected automatically when the drive is removed (except Selsyn, Style 102 and 101MS, which has screw terminals.)

Oiling will be necessary after 3 to 5 years service, depending on the temperature at which the drive operates and the amount of dirt and dust which gets into the drive. After 5 to 10 years service drives should be sent to the factory for complete overhauling.

Oils specified below are available from The Esterline-Angus Company and are for use on chart drives operating at normal temperatures of 20° to 100°F. Temperatures outside of this range require special lubrication. Consult the factory. In using these oils it is well to remember that too much lubrication is almost as bad as too little. Do Not Overoil.

Nye's Superior Clock Oil - 1/3 oz. Bottle. Spring chart drive escapements only. Use sparingly.

E-A 40 Oil - 1 oz. Bottle. Spring, synchronous and motor-wound chart drives. Porous bronze and all pivot bearings in these drives except escapements in spring drives. Do not oil ratchets and pawls. They operate better if run dry.

E-A Mainspring Grease - 4 oz. Can. For use on mainsprings of spring chart drives and worm winding gear. Springs seldom need regreasing and the drive must be partially taken apart to do this greasing. It is well to do this work in a meter repair shop or return the drive to the factory. Instructions are furnished with the grease.

For convenience in applying the oil a wire applicator, Part No. 5775, is supplied. Dip the wire in the oil and touch it to the bearing. The oil will feed itself into the bearing.

Synchronous Motors Are Lubricated For Life. Do Not Try To Relubricate. Removing motors from synchronous drives requires major disassembly and should be done only at the factory or in a well-equipped instrument shop. Before attempting to disassemble any part of the drive, see separate instructions in this book for the type and style of chart drive in your particular instrument.

Synchronous Drives, Style 90-M and 90-MS

Style	TYPE	Standard Chart Speeds: Inches Per Hour	Standard Chart Speeds: Inches Per Minute	Speed Change Mechanism	RECOMMENDATIONS
90-M	Synchronous, Hour and Minute Feed	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	Manual	Use where frequency regulated AC is available, where it is not necessary for record to continue during power supply interruption, and where rapid fluctuations of the measured quantity occur.
90-MS	Synchronous, Hour and Minute Feed with Electric Shift	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	Manual or Electric	Use where frequency regulated AC is available, where it is not necessary for record to continue during power supply interruptions, where rapid fluctuations of the measured quantity occur, and where a change from hour to minute feed must be made automatically or from a remote point.

These drives are equipped with take-over clutch and through shaft for coupling to a phantom, external motor attachment or other external driving source. They should not be coupled to each other. If the external driving source can reverse, the internal drive must be equipped with a back-up clutch, and coupling must be on the right-hand side.

The chart drive nameplate and the terminal marking on the back of the meter show the frequency and the nominal voltage. Operating limits are ±15% of nominal voltage. Each drive contains two motors, the synchronous timing motor and an induction motor driving the reroll. Both motors are controlled by a single "Start-Stop" switch.

Unwinding the Reroll Spring - The reroll gear train can be replaced as a unit or the reroll storage spring assembly only can be replaced. In either case, be sure to let down the reroll spring before attempting disassembly. With power off, hold the chart reroll roller in the hand and let it revolve slowly, with power off, until it does not turn. Damage may result if disassembly is attempted with energy stored in the spring.

Motor and Electric Shift Coil Data — Style 90-M and 90-MS Chart Drives

Rating	Combined Load of Timing and Reroll Motors: VA	Watts	Amperes	Reroll Motor Only: VA	Watts	Amperes	Electric Shift Coils*: VA	Watts	Amperes
6 Volts DC	.....	.....	.....	.....	.....	.....	.....	10	1.7
12 Volts DC	.....	.....	.....	.....	.....	.....	.....	10	0.8
24 Volts DC	.....	.....	.....	.....	.....	.....	.....	10	0.4
48 Volts DC	.....	.....	.....	.....	.....	.....	.....	10	0.2
125 Volts DC	.....	.....	.....	.....	.....	.....	.....	10	0.08
250 Volts DC	.....	.....	.....	.....	.....	.....	.....	10	0.04
120 Volts, 60 Cycles	23	10.5	0.19	15	6	0.13	13	5	0.11
240 Volts, 60 Cycles	23	10.5	0.09	15	6	0.07	13	5	0.06
120 Volts, 50 Cycles	26	13	0.21	15	6	0.13	16	6	0.14
240 Volts, 50 Cycles	26	13	0.11	15	6	0.07	16	6	0.07
120 Volts, 25 Cycles	17	9.5	0.14	9	4	0.08	13	6	0.11
240 Volts, 25 Cycles	17	9.5	0.07	9	4	0.04	13	6	0.06

*All AC shift coils are designed for continuous operation. DC shift coils should be energized intermittently, not more than 5 minutes on, followed by an equal off period.

Spring Chart Drives

No.	TYPE	Standard Chart Speeds		Speed Change Mechanism	RECOMMENDATIONS
		Inches Per Hour	Inches Per Minute		
80-H	Hand-wound Spring, Hour Feed	¾, 1½, 3, 6, 12	.....	.....	Use where chart drive must be entirely independent of any power supply, and where rapid fluctuations of the measured quantity do not occur.
80-M	Hand-wound Spring, Hour and Minute Feed	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	Manual	Use where chart drive must be entirely independent of any power supply and where rapid fluctuations of the measured quantity are to be studied.
80-MS	Hand-wound Spring, Hour and Minute Feed, with Electric Shift	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	Manual or Electric	Use where normal chart drive operation must be entirely independent of any AC power supply, where rapid fluctuations of the measured quantity occur, and where change from hour to minute feed must be made automatically or from a remote point.
101-H	Motor-wound Spring, Hour Feed	¾, 1½, 3, 6, 12	.....	.....	Use where AC is available, where record must be independent of power supply interruption, and where rapid fluctuations of the measured quantity do not occur.
101-M	Motor-wound Spring, Hour and Minute Feed	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	Manual	Use where AC is available, where record must be independent of power supply interruption, and where rapid fluctuations of the measured quantity are to be studied.
101-MS	Motor-wound Spring, Hour and Minute Feed with Electric Shift	¾, 1½, 3, 6, 12	¾, 1½, 3, 6, 12	Manual or Electric	Use where AC is available, where record must be independent of power supply interruption, rapid fluctuations of the measured quantity occur and change from hour to minute feed must be made automatically or from a remote point.

All of these chart drives are equipped with take-over clutch and have through shaft for coupling to each other, to a phantom, to an external motor attachment or other external driving source. If the external driving source can reverse, the internal drive must be equipped with a back-up clutch, and coupling must be on the right-hand side.

Hand-wound and motor-wound spring chart drives are timed by escapements. The same escapements are used in both types. The hour feed escapement will provide only hour feeds. The minute feed escapement contains both the hour-feed timing mechanism and a flyball governor to time minute feeds. An hour feed chart drive, can be changed to minute feed by changing escapements. A third type of escapement is used in drives equipped with an electric shift for automatic change from hour to minute feeds.

Regulating the Chart Timing - All escapements are regulated and given two long test runs before shipment. The balance wheel is temperature compensated. It is seldom necessary to change the regulation. The regulator lever is visible through the slot in the nameplate. To regulate the hour feed timing, move the regulator up to make the drive run faster and down to make it run slower. Although not all escapements respond alike, a movement of one division on the regulator scale affects the timing approximately four minutes per day.

The regulation of chart speed on minute feeds is accomplished by turning the small screw located above the control lever on the escapement. Direction to turn for faster or slower adjustments is shown by the arrows. This adjustment is very sensitive. Turn the screw slightly and note the effect on the chart speed.

Removing the Escapement Unit - The escapement assembly is a complete unit in itself and it can be removed without taking the chart drive apart. First, the chart drive must be removed from the case and the springs unwound. See instructions on page 5 or 6. The escapement can then be taken out by removing the control lever and the three black screws which hold the escapement to the left-hand side plate of the drive. The escapement is accurately positioned by two dowell projections on the plate. This insures correct mesh of the gear which drives the escapement with the pinion in the escapement. Pull escapement off of the dowells and remove carefully. A pair of flat nosed pliers to hold the right hand plate of the escapement will help to remove it safely.

If trouble develops in the escapement, it should be replaced with a new escapement. Repairs to escapements, outside of our factory, are not recommended. If a spare escapement is carried in stock, the instrument need not be taken out of use. Install the spare escapement in the chart drive, and return the worn escapement to the factory for repair.

Hand-Wound Spring Drives, Style 80-H, 80-M and 80-MS

Hand-wound spring chart drives are shipped stopped; the springs are wound. The power for feeding the chart is stored in four identical springs connected in series. The springs are wound simultaneously.

To wind, insert the square end of the winding crank into the winding arbor, push the arbor in as far as it will go and, at the same time, turn steadily in a clockwise direction. When the springs are fully wound, the winding crank will refuse to turn. Be sure that the chart drive is fully wound before stopping. A partial turn in the reverse direction, at the same time withdrawing the winding crank, completes the winding operation. The winding arbor is forced out to its original position by a spring which disengages the worm from the worm gear inside the housing.

If the springs have been unwound completely, it requires about 110 turns of the winding crank to rewind them. The chart drive is designed to operate for eight days at any of the standard hour feeds. Approximately 65 turns are required to replace the energy used in eight days operation. Winding once per week or each time the chart is renewed (whichever is oftener) is recommended.

Starting and Stopping the Chart Drive - The chart is started by raising the control lever on the left side of the chart drive up from stop position to the hour feed mark for hour feeds, and to the minute feed mark for minute feeds. A white target, visible through the small window at the left edge of the chart, moves up and down when the escapement is running. If the escapement does not start immediately, move the control lever up and down a few times. When the chart is started in minute feed, there is a slight lag in getting up to correct speed. This is due to the flyball governor, which requires time to reach full speed. When running the chart at minute feeds, wind the springs after every four hours of continuous operation.

Unwinding the Springs - Before undertaking any repair work on the chart drive, the springs must be completely unwound. This is very important; failure to unwind the springs may release their power suddenly and damage the chart drive. To let down or unwind the springs, take the chart drive out of the case. Remove the chart reroll and then take off the reroll gear cover by removing the four screws holding it in place. Lay the drive on its back. Insert the winding crank with the right hand and push the reroll release pin to the left. This pin projects out of the left hand side plate. Its location is shown on the instruction plate. The release pin will slide easily if the crank is held so the pressure on the pin is relieved. Do not force it over. Holding firmly to the winding crank, allow it to turn slowly in a counter-clockwise direction until the springs are completely unwound. Springs are unwound when the crank no longer tries to turn. Do not let go of the crank until the springs are unwound. When the work for which the springs have been let down is completed, push the reroll release pin to the right, into its original position and replace the reroll gear cover.

Removing the Spring Assembly - To remove the spring assembly, the chart drive must first be taken out of the instrument case. Let down the springs according to the directions in the preceding paragraph. Take off the winding bracket by removing the four screws which hold it to the right side plate. With the instruction plate off, the spring assembly can be withdrawn through the hole in the right side plate. New spring assemblies can be installed and the winding bracket replaced. The springs are ready for winding. Where several recorders with hand-wound spring drives are in use, it is desirable to keep one or two spare springs on hand.

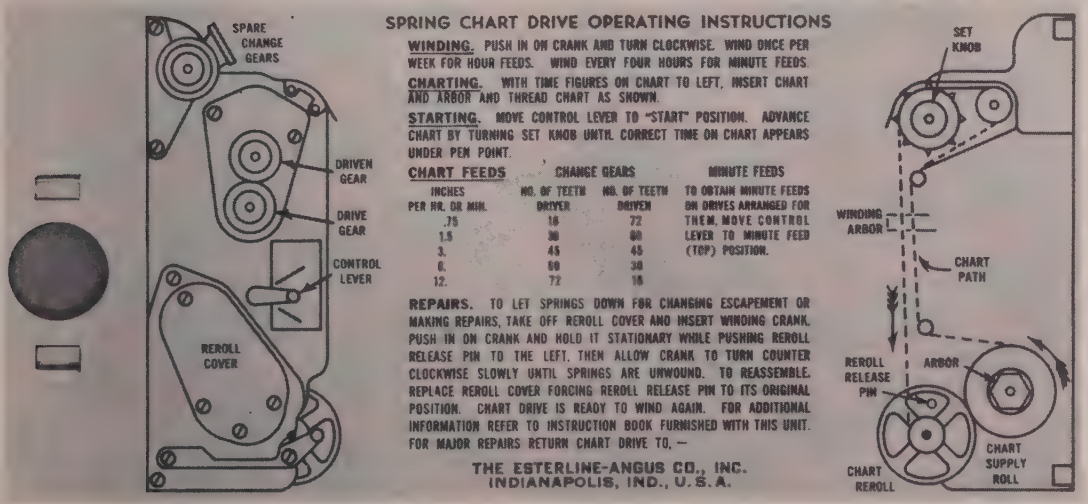

SPARE CHANGE GEARS
DRIVEN GEAR
DRIVE GEAR
CONTROL LEVER
REROLL COVER
SPRING CHART DRIVE OPERATING INSTRUCTIONS
WINDING. PUSH IN ON CRANK AND TURN CLOCKWISE. WIND ONCE PER WEEK FOR HOUR FEEDS. WIND EVERY FOUR HOURS FOR MINUTE FEEDS.
CHARTING. WITH TIME FIGURES ON CHART TO LEFT, INSERT CHART AND ARBOR AND THREAD CHART AS SHOWN.
STARTING. MOVE CONTROL LEVER TO "START" POSITION. ADVANCE CHART BY TURNING SET KNOB UNTIL CORRECT TIME ON CHART APPEARS UNDER PEN POINT.
CHART FEEDS
CHANGE GEARS
MINUTE FEEDS
INCHES PER HR. OR MIN.
NO. OF TEETH DRIVER
NO. OF TEETH DRIVEN
.75 18 72
1.5 36 60
3. 45 45
6. 60 30
12. 72 15
TO OBTAIN MINUTE FEEDS ON DRIVES ARRANGED FOR THEM, MOVE CONTROL LEVER TO MINUTE FEED (TOP) POSITION.
REPAIRS. TO LET SPRINGS DOWN FOR CHANGING ESCAPEMENT OR MAKING REPAIRS, TAKE OFF REROLL COVER AND INSERT WINDING CRANK. PUSH IN ON CRANK AND HOLD IT STATIONARY WHILE PUSHING REROLL RELEASE PIN TO THE LEFT. THEN ALLOW CRANK TO TURN COUNTER CLOCKWISE SLOWLY UNTIL SPRINGS ARE UNWOUND. TO REASSEMBLE, REPLACE REROLL COVER FORCING REROLL RELEASE PIN TO ITS ORIGINAL POSITION. CHART DRIVE IS READY TO WIND AGAIN. FOR ADDITIONAL INFORMATION REFER TO INSTRUCTION BOOK FURNISHED WITH THIS UNIT. FOR MAJOR REPAIRS RETURN CHART DRIVE TO, —
THE ESTERLINE-ANGUS CO., INC.
INDIANAPOLIS, IND., U.S.A.
SET KNOB
WINDING ARBOR
CHART PATH
REROLL RELEASE PIN
ARBOR
CHART SUPPLY ROLL
CHART REROLL

Fig. 4 — A single control lever starts and stops the chart drive and is also the manual shift lever, Style 80-M. Style 80-MS has an electric shift for changing hour-to-minute feeds.

Motor-Wound Spring Drives, Style 101-H, 101-M, 101-MS

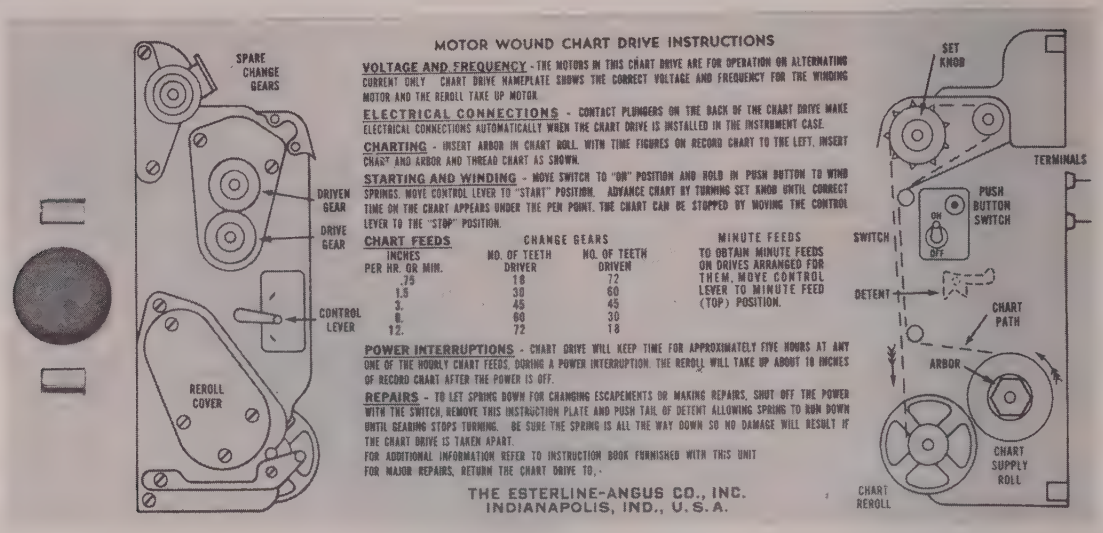

SPARE CHANGE GEARS
DRIVEN GEAR
DRIVE GEAR
CONTROL LEVER
REROLL COVER
MOTOR WOUND CHART DRIVE INSTRUCTIONS
VOLTAGE AND FREQUENCY - THE MOTORS IN THIS CHART DRIVE ARE FOR OPERATION ON ALTERNATING CURRENT ONLY. CHART DRIVE NAMEPLATE SHOWS THE CORRECT VOLTAGE AND FREQUENCY FOR THE WINDING MOTOR AND THE REROLL TAKE UP MOTOR.
ELECTRICAL CONNECTIONS - CONTACT PLUNGERS ON THE BACK OF THE CHART DRIVE MAKE ELECTRICAL CONNECTIONS AUTOMATICALLY WHEN THE CHART DRIVE IS INSTALLED IN THE INSTRUMENT CASE.
CHARTING - INSERT ARBOR IN CHART ROLL. WITH TIME FIGURES ON RECORD CHART TO THE LEFT, INSERT CHART AND ARBOR AND THREAD CHART AS SHOWN.
STARTING AND WINDING - MOVE SWITCH TO "ON" POSITION AND HOLD IN PUSH BUTTON TO WIND SPRINGS. MOVE CONTROL LEVER TO "START" POSITION. ADVANCE CHART BY TURNING SET KNOB UNTIL CORRECT TIME ON THE CHART APPEARS UNDER THE PEN POINT. THE CHART CAN BE STOPPED BY MOVING THE CONTROL LEVER TO THE "STOP" POSITION.
CHART FEEDS
INCHES PER HR. OR MIN.
CHANGE GEARS
NO. OF TEETH DRIVER
NO. OF TEETH DRIVEN
.75 18 72
1.5 30 60
3. 45 45
6. 60 30
12. 72 18
MINUTE FEEDS
TO OBTAIN MINUTE FEEDS ON DRIVES ARRANGED FOR THEM, MOVE CONTROL LEVER TO MINUTE FEED (TOP) POSITION.
POWER INTERRUPTIONS - CHART DRIVE WILL KEEP TIME FOR APPROXIMATELY FIVE HOURS AT ANY ONE OF THE HOURLY CHART FEEDS, DURING A POWER INTERRUPTION. THE REROLL WILL TAKE UP ABOUT 18 INCHES OF RECORD CHART AFTER THE POWER IS OFF.
REPAIRS - TO LET SPRING DOWN FOR CHANGING ESCAPEMENTS OR MAKING REPAIRS, SHUT OFF THE POWER WITH THE SWITCH, REMOVE THIS INSTRUCTION PLATE AND PUSH TAIL OF DETENT ALLOWING SPRING TO RUN DOWN UNTIL GEARING STOPS TURNING. BE SURE THE SPRING IS ALL THE WAY DOWN SO NO DAMAGE WILL RESULT IF THE CHART DRIVE IS TAKEN APART.
FOR ADDITIONAL INFORMATION REFER TO INSTRUCTION BOOK FURNISHED WITH THIS UNIT FOR MAJOR REPAIRS, RETURN THE CHART DRIVE TO,
THE ESTERLINE-ANGUS CO., INC.
INDIANAPOLIS, IND., U.S.A.
SET KNOB
TERMINALS
PUSH BUTTON SWITCH
ON
OFF
SWITCH
DETENT
CHART PATH
ARBOR
CHART SUPPLY ROLL
CHART REROLL

Fig. 5 — Location of the motor control switch, start-stop lever and the push button switch to wind the springs is shown on the instruction plate.

The motor-wound spring chart drive is unique in that the drive continues to operate after power service is interrupted. Synchronous chart drives stop instantly when power fails and no record is made of what happens during a power interruption or how long the power was off.

Motor-wound chart drives can be operated from circuits in which the frequency is not closely regulated. The power to wind the mainspring is supplied by a stalled induction motor. Another similar motor rerolls the record chart as required. Both motors are energized periodically by means of a cam operated switch. The reroll motor train includes a small storage spring which is normally wound up by the motor. When the power goes off this spring will reroll a minimum of 18 inches of chart which is 24 hours on the chart at 3/4" per hour, 12 hours at 1 1/2" and 6 hours at 3" per hour. The chart feed and reroll on any instrument equipped with a motor-wound spring chart drive will operate at any standard hour feed for about 5 hours after power is off.

Starting and Stopping the Chart Drive - The chart is started by moving the switch on the right hand side to the "on" position and moving the control lever, on the left hand side, from stop to hour feed for hour feed or to the minute feed mark for minute feed. Placing the switch in the "off" position shuts off both motors.

If the power is off longer than five hours and the escapement stops beating it will be necessary to hold in the push button on the right hand side of the drive for about 1 1/2 minutes to rewind the springs. They are fully wound when the winding noise ceases. At any time that the timing spring or the storage spring on the reroll inadvertently becomes unwound they should be rewound by holding in the push button switch to restore normal operation.

After the springs are wound be sure the escapement is running by looking at the target through the peep hole. If the escapement is stopped give it a start by moving the control lever.

Unwinding the Springs - Before undertaking any repair work on the chart drive, the mainspring must be completely unwound. Failure to unwind the springs will release power suddenly and damage the chart drive. To let down or unwind the mainspring, take

Electric Shift Coils — Style 80-MS and 101-MS Drives

Rating of Shift Coil†	VA	Watts	Amperes
6 Volts DC	.....	1.3	0.21
12 Volts DC	.....	1.3	0.11
24 Volts DC	.....	1.4	0.06
48 Volts DC	.....	1.4	0.03
24 Volts, 25 Cycles	1.9	1.4	0.08
24 Volts, 50-60 Cycles	2.4	1.3	0.10
120 Volts, 50-60 Cycles	2.4	1.4	0.02

†Both AC and DC Shift Coils are designed for continuous operation.

Motors — Style 101-H, 101-M and 101-MS Drives

Motor Rating	VA*	Watts*	Amperes*
120 Volts, 60 Cycles	15	6	0.13
240 Volts, 60 Cycles	15	6	0.07
120 Volts, 50 Cycles	15	6	0.13
240 Volts, 50 Cycles	15	6	0.07
120 Volts, 25 Cycles	9	4	0.08
240 Volts, 25 Cycles	9	4	0.04

*Total load of chart drive is twice these figures.

the instruction plate off of the front of the drive. Shut off the power with the switch and push in on the tail of the detent, allowing the spring to run down until the gearing stops turning. This detent is located in the middle of the opening made by removing the instruction plate, on the inside of the right side plate.

The reroll storage spring must also be unwound before removing the reroll train. Let the reroll roller turn slowly in the hand until the spring is completely run down.

Phantom Drives, Style 81-P, 91-P, 82-P, 92-P, 82-PC and 92-PC

No.	Type	Chart Travel	Recommendations
81-P	Spring reroll, without clutches	Phantom drives contain no power unit. One revolution of coupling shaft propels ¾, 1½, 3, 6 or 12 inches of paper under pen point with corresponding gears in place. Furnished complete with coupling. See section on Driving Chart from an External Source, page 14	Use in twin meter equipped with spring drive. Also where chart motion is proportional to some quantity other than time, no AC is available and driving source has restraining torque when chart is not in motion.
82-P	Spring reroll, with drag clutch		Use where chart motion is proportional to some quantity other than time, no AC is available and driving source has no restraining force when chart is not in motion. Use with external motor.
82-PC	Spring reroll, with drag and back-up clutches		Use where chart motion is proportional to some quantity other than time, no AC available, driving source has no restraining force and can reverse rotation. Coupling must be made on right side.
91-P	Electric reroll, without clutches		Use in twin meter equipped with synchronous or motor-wound spring chart drive. Also where chart motion is proportional to some quantity other than time, AC is available and driving source exerts restraining torque when chart is not in motion.
92-P	Electric reroll, with drag clutch		Use where chart motion is proportional to some quantity other than time, AC is available and driving source does not exert restraining force when chart is not in motion.
92-PC	Electric reroll, with drag and back-up clutches		Use where chart motion is proportional to some quantity other than time, AC is available, driving source exerts no restraining force and can reverse rotation. Coupling must be made on right side.

Electric reroll motors are the same as those used in Style 90-M and 90-MS, See table page 3.

Phantom chart drives are modifications of the series 80-90 power driven, spring and synchronous motor chart drives. They do not have an inherent source of power for feeding the record chart. The instructions for threading the chart and changing gears to obtain various chart feeds are covered in the instructions pertaining to power chart drives. Phantom chart drives are used to feed the chart by some driving means provided outside of the drive. This source of power is commonly a power chart drive installed in one side of a twin recorder.

All phantom drives have means for rerolling the used record chart. In the Series 80 styles, the power to reroll is supplied by springs. These springs must be wound with the winding crank by pushing in on the crank and turning in a clockwise direction until the springs are wound. Full winding requires about 55 turns of the crank. Wind each time the chart is replaced with a new chart.

The electric phantoms (Series 90 styles) use the same reroll take-up motor and reroll gear train as the synchronous drives. Power requirements of the motor are the same as those shown for the reroll motors of synchronous drives.

When the application of an E-A instrument or a phantom chart drive requires that it be driven from some external shaft or motor, the driving member should be attached to the coupling shaft by means of a flexible coupling. The ends of the coupling shaft are fitted with a ball and cross pin which engages the slotted coupling head. The Esterline-Angus Company can furnish a variety of couplings or simply a coupling head so the user can make up his own coupling shaft. This arrangement is used for coupling when the record chart is to be driven at a rate proportional to something other than time. The movement to be recorded may be proportional to the distance traveled by a vehicle, the depth of a well, the movement of a machine table, etc. In such applications, clutches are built into the drive so it will operate properly.

Selsyn Drives, Style 102

These chart drives are similar to the synchronous chart drives, Series 90, having the same chart drive frame, rollers, etc., and the same electric reroll, but the chart is driven by a G.E. Style 2JD55B1, 115 volt, 60 cycle Selsyn instead of the usual synchronous motor. Standard chart feeds are:

Change Gears (Number of Teeth)		Inches of Chart Per Revolution of Selsyn
Driver	Driven	
18	72	1/4
30	60	1/2
45	45	1

The Selsyn speed should not exceed 180 RPM which corresponds to a chart speed of 3 inches per second.

Connections for the transmitting and receiving Selsyns are shown on diagram No. S-5168. The five connections to the back of the chart drive are made with screw terminals instead of the jack plug terminals used on other E-A chart drives. Flexible leads run from these terminals to those on the terminal blocks of the instrument as shown on diagram No. S-5168.

Special Drives

Synchronous drives furnished with Model G2 timing motor (instead of Model G) produce chart speeds twice normal. Model G2.5 timing motor gives speeds 2 1/2 times normal. Special drives having built-in 4:1 reduction gearing are furnished to suit particular requirements for slow chart speeds.

For some applications drives are furnished locked in minute feed and no hour feeds are available with these drives.

All special chart drives have a blank cover plate, as do phantom chart drives. The special features of any drive are listed on the Instrument Data Sheet. Inserting the chart and setting up for operation are the same as shown in the illustrations, pages 10-12 of this section.

The chart speeds produced by these drives with the various change gears in place are as follows:

Change Gears (Number of Teeth)		Chart Speeds, Inches per Hour and Per Minute		
		Special Synchronous Motors		4:1 Reduction Gearing
Driver	Driven	Model G2	Model G2.5	
18	72	1-1/2	1-7/8	3/16
30	60	3	3-3/4	3/8
45	45	6	7-1/2	3/4
60	30	12	15	1-1/2
72	18	24	30	3

External Motor Attachments

Style		Chart Speeds Inches per Second	Motor Rating			Recommendations
			DC Volts	AC Volts	AC Frequency	
24	Second Feed non-reset	¾, 1½, 3*	12, 24, 48, 125, 250	120	50, 60	Use where time of day of the rapid variation of the measured quantity is not important and length of high-speed runs may be variable.
22	Second Feed, with Time Reset	¾, 1½, 3*	24, 48, 125, 250	120	50, 60	Use where time of day of the rapid variation of the measured quantity is important. These drives reset the chart to correct time of day at the end of each high-speed run.

*When combined with 101-H, 101-M or 101-MS internal chart drive, use only 3/4 inch per second.

Style 24, Type N, non-reset, drive consists of a fractional HP motor and gear box. To start the chart at high speed, it is only necessary to energize the motor. This can be done with the switch on the top of the gear box, or this switch can be left in the "on" position and the motor started by closing another switch or a pair of relay contacts at some remote point. The chart continues to run at high speed as long as the motor is energized and stops when it is de-energized.

Style 22, Type R, Reset, drive operates in the same manner as Type N, except that it resets the chart to the correct time of day after each high-speed operation. It must be energized from an unfailing supply.

The chart is started at high speed by energizing the motor which is accomplished by closing the trip circuit. This is usually done by a pair of relay contacts. For test purposes, a momentary contact button on the top of the gear box will also start the drive. The Type R drive has a lock-in circuit, and continues to run until the correct time of day is under the pen point and then stops. Hence, the start of any succeeding disturbance will show at the correct time on the chart. To insure lock-in, the trip circuit must remain closed approximately 1/5 second.

Both types of external motors are available for either AC or DC. The AC motors are synchronous. The rheostat furnished with all DC drives permits adjusting the motor speed to exactly 1800 RPM.

Mounting - On front switchboard or wall mounting recorders, the external drive can be left in place while the meter is being mounted. On flush switchboard instruments, the external motor drive must be removed while the recorder is placed in the panel. Then it must be re-attached to the meter case. Be sure that the coupling between the motor drive and the instrument coupling shaft has end play and is free in all positions. If the internal chart drive is to be removed from the recorder, it is necessary to loosen the external motor drive to permit removal of the coupling. It is not necessary to remove the external drive entirely.

Change Gears - The change gears on the internal chart drive determine the chart speed. Consult the instruction plate on the front of the internal chart drive. The external motor drive moves the chart at 3600 times normal hour speed. Usually, 3/4 inch per second is recommended as this speed is high enough to record any variations that the recorder pen can follow. Speeds of 1 1/2 and 3 inches per second can be used, if necessary. External motor attachments used with motor-wound spring internal drives must be used only at 3/4 inch per second.

Chart Reroll - If the internal chart drive is spring powered, the reroll unit is completely independent and will continue to operate in normal fashion through any failure of electrical power which may affect other parts of the recorder.

In the internal synchronous and motor-wound spring chart drives, the reroll gear train is provided with a small storage spring which will take up about 18 inches of chart after the reroll motor stops. This means that a chart drive using 3/4" per hour normal chart feed and 3/4" per second chart feed at high speed will reroll one high speed operation with a Type R, Reset, external motor drive.

Writing System - Instruments with external motor attachments require more careful attention to the inking system than is the case with a recorder operating at hour and minute speeds. This is due to the much more rapid flow of ink required in these instruments and the fact that this increased ink flow must often start very suddenly. In such instruments we recommend that the inkwell and pen, or pens, be emptied, washed and refilled once each week. See instruction section IS10.

The pen pressure must be sufficient to hold the pen on the chart even when it is swinging rapidly. For high speed recording, the pen should bear on the paper somewhat heavier than for the ordinary instrument, but the pen, full of ink, should always bounce slightly off of the paper when the pen table is tapped (except operation recorders.)

Care of Charts - We recommend the use of E-A charts and do not guarantee accuracy unless our charts are used. For instruments with high speed attachments, it is important that the chart be kept clean and dry, that it be threaded properly in the instrument and properly attached to the reroll and that the reroll spring (in drives with spring powered rerolls) be fully wound each time a new chart roll is inserted. Damp charts or dust on the chart surface or on the writing pen will interfere with proper high speed recording. Keep the case cover or door closed at all times. These precautions are necessary so that the chart will feed smoothly over the writing table and will be kept taut at all times. If the chart bulges or wrinkles due to being damp or improperly threaded in the instrument, the pen will skip when swinging rapidly.

In instruments where the high speed action occurs only intermittently, (particularly Type R) the instrument should be examined at regular intervals to see that there is enough chart left on the supply roll. The amount of unused chart can be seen by looking through the slot in the right hand side plate. It is a good practice to date the record daily to identify the day of occurrence of any high speed operations.

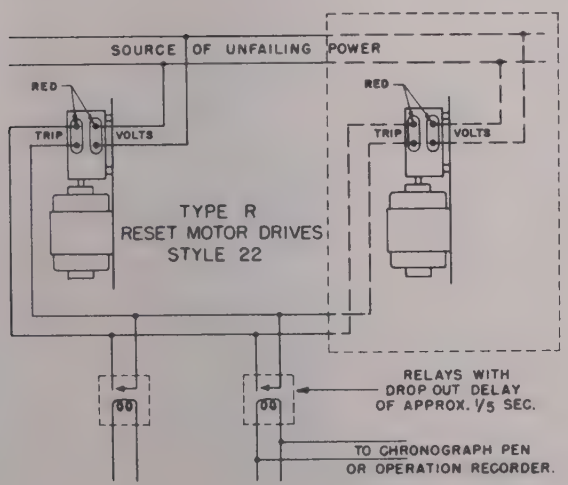
Adding in the Field - An external motor drive device can be installed in the field. Information will be furnished upon request. Be sure to specify the recorder serial number.

Ratings Available and Electrical Data

Rating	Volt-Amperes	Watts	Starting Amperes	Running Amperes
12 Volts DC	..	22	8.0	1.80
24 Volts DC	..	22	4.0	0.90
48 Volts DC	..	22	2.0	0.45
125 Volts DC	..	22	0.7	0.18
250 Volts DC	..	22	0.35	0.09
120 Volts, 50 cycles	60	23	5.0	0.50
120 Volts, 60 cycles	62	23	5.0	0.52

DRIVING THE CHART FROM AN EXTERNAL SOURCE

Hand-wound spring, motor-wound spring and synchronous chart drives are equipped with internal clutches so the chart can be driven from an external source or by an External Motor Attachment without damaging the internal mechanism. When the external source can reverse direction, the internal chart drive must also be equipped with a back-up clutch.



The typical connection diagram at the left shows how Type R Style 22 motor drives can be operated with one or more circuits connected to supply the initiating impulse. One or more additional Style 22 drives can be connected in parallel with the first unit as shown in the dotted box. Polarity of both Trip and Volts circuits must be observed.

PLACING A RECORDER IN OPERATION

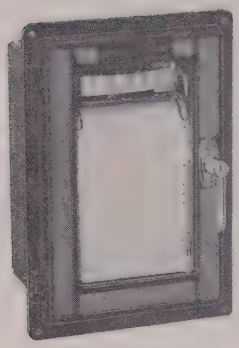


Fig. 6 – Flush cases have a lock in the handle and the door is hinged on the left. The chart and scale are illuminated by a 4-watt, 120 volt, 60 cycle fluorescent lamp. An incandescent lamp is used for certain other voltages and frequencies.

Fig. 7 – Portable, front switchboard and wall cases are sealed for shipment. To open these cases, break the seal, open the latch and swing the cover open 3-5 inches. Then slide the lower end of the cover in toward the meter case and lift it off the hinge hooks.

The following illustrations apply to all E-A recorders. Wherever the procedure for operation recorders differs from other meters a separate illustration is used. See Figs. 10, 21, 23, 25 and 28.

Fig. 8 – Carefully remove the pen element from the tie-up card. Be sure the pen tube is not bent in removal.

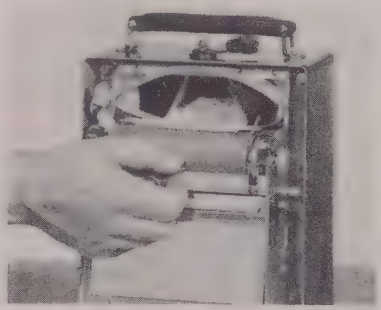


Fig. 9 – Raise the scaleplate, remove the tie-up card and cut the string holding the change gears in place.

Fig. 10 – Operation Recorder Only – Cut the string holding the pen elements and scaleplate. Tilt scaleplate and remove the tie-up card.

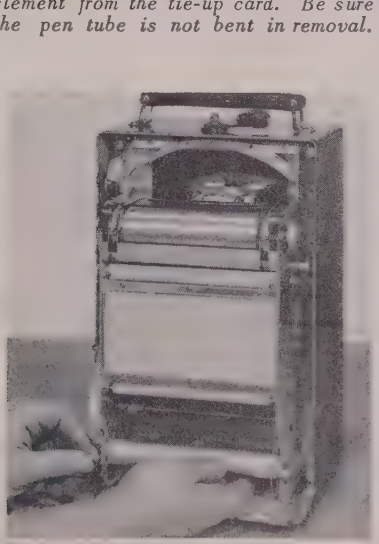


Fig. 11 – Press down the reroll latch, either left or right, and remove the reroll roller.

Fig. 12 – Grasp the supply roll arbor, lift up and pull forward to remove.

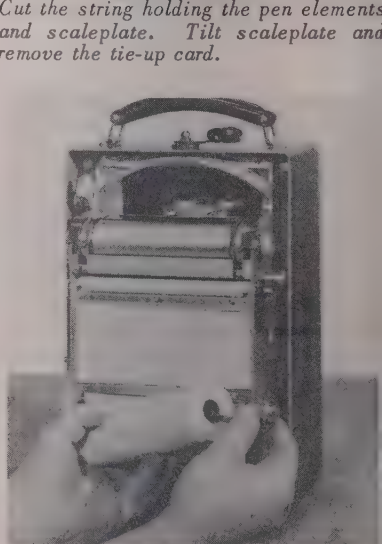
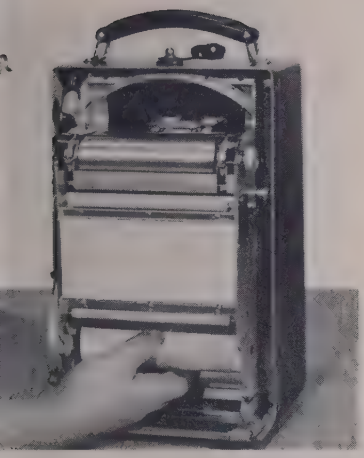


Fig. 13 – Insert the arbor in the chart core, and center it, with elongated chart perforations to the right.



. 14 – Push new chart in place. pply arbor must snap in its slots and rt roll turn freely.

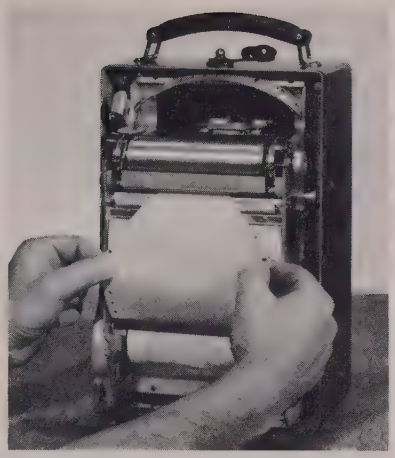


Fig. 15 – Tear or cut end of chart to a "V". Feed chart into slot marked "Insert End of Chart Here".

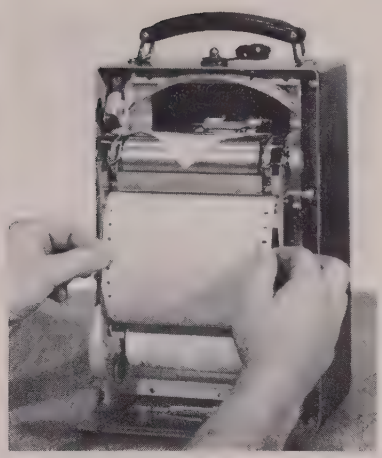
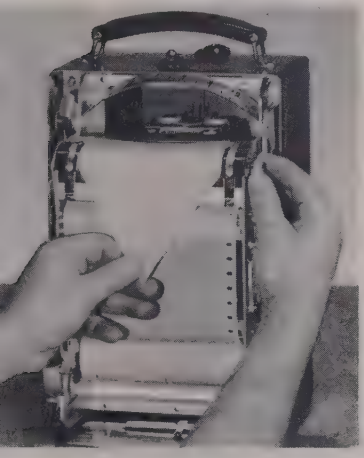


Fig. 16 – Push chart into the slot until the point hangs over the drive roll.



g. 17 – Turn the knurled set knob on ve roll ahead, and pull the chart refully until the drive roll pins engage chart perforations.

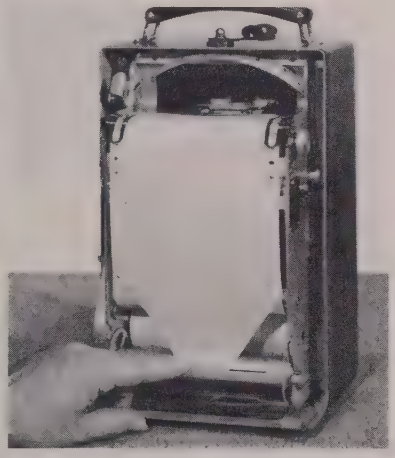


Fig. 18 – Snap the reroll roller in place, gear end to the left. Insert "V" end of chart into slot in the roller and crease. Turn reroll roller back about 1/4 turn to release brake.

Fig. 19 – Turn the set knob forward with the right hand while allowing the reroll to turn forward in the left hand. Be sure that the chart rolls smoothly on the reroll.

g. 20 – Grasp the wire handles of inkwell and lift up and forward to move it from the meter.

Fig. 21 – Operation Recorder Only – Grasp operation recorder inkwell bail handle. Lift up and over the pen lifter removing both inkwell and pens.

Fig. 22 – With the inkwell filler, transfer E-A ink from the bottle to the inkwell. Fill the inkwell a little over half full.

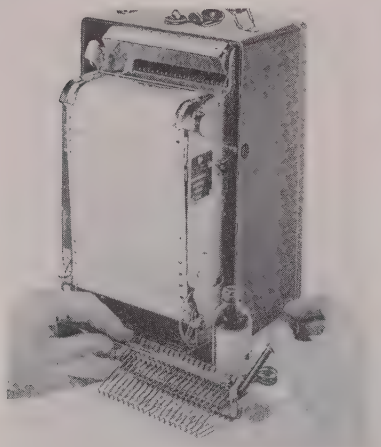


Fig. 23 – Operation Recorder Only – Use the inkwell filler to transfer E-A ink from the bottle to the inkwell. Fill the inkwell a little over half full.

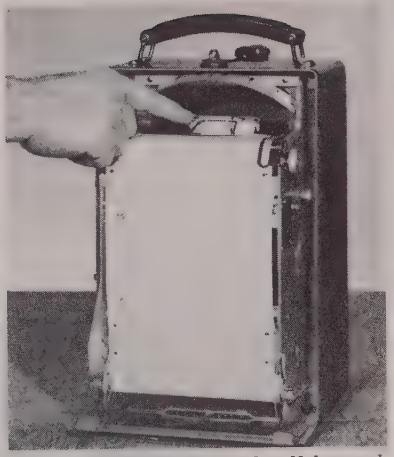


Fig. 24 – Replace the inkwell by pushing it under the spring holder prongs and allow it to slide forward, sitting level.

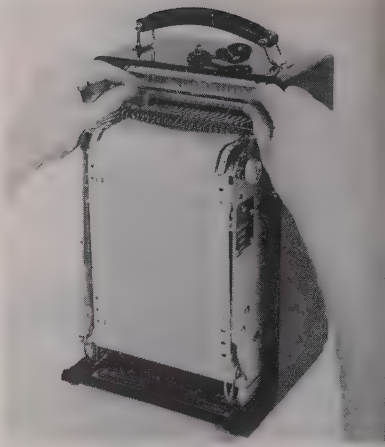


Fig. 25 – Operation Recorder Only – Replace inkwell and pen elements. Be sure that pen tails engage lever arms and that inkwell seats firmly. Do not tip inkwell during replacement.

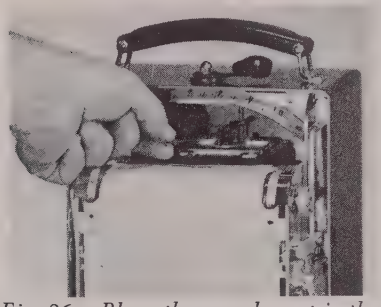


Fig. 26 – Place the pen element in the pen fork. (Left handed is easiest.) Pen must balance freely on its knife edge. The point will remain off the chart until the pen is filled with ink.

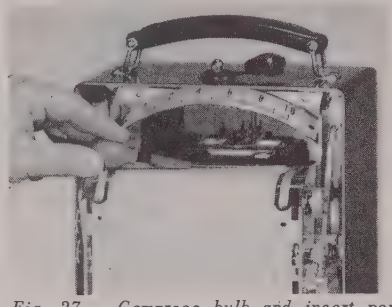


Fig. 27 – Compress bulb and insert pen point in the hole in the tip of the pen filler. Release the bulb slowly until ink appears in the glass tube of the pen filler. Wash the pen filler with water after servicing the meter.

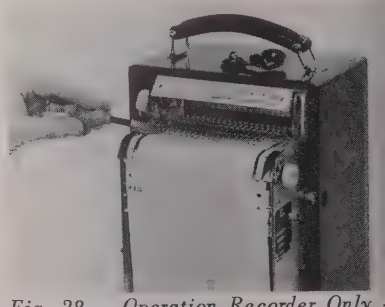


Fig. 28 – Operation Recorder Only – Repeat procedure of Fig. 27 with each pen. A pair of tweezers will facilitate lifting each pen and inserting it in the hole in the pen filler.

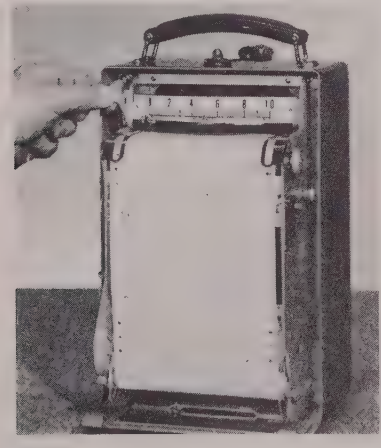


Fig. 29 – Check to see that proper change gears are in place to match the time markings on the chart. The instruction plate shows the proper gears to use for each standard speed.

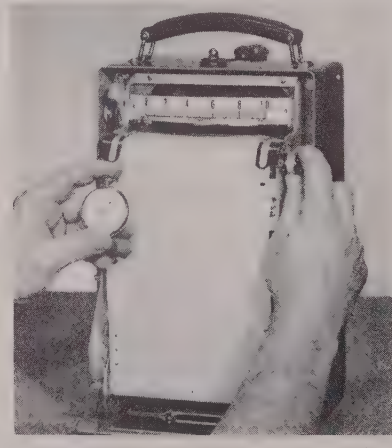


Fig. 30 – Turn the knurled set knob ahead until the correct time of day appears under the pen point. Turn the chart drive "Start-Stop" switch on.

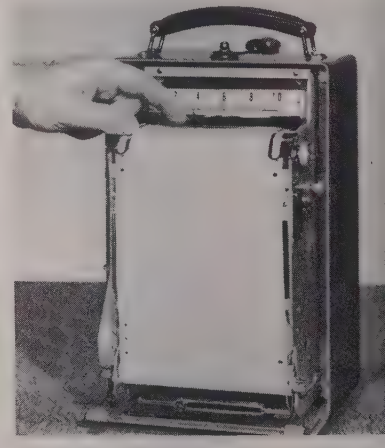


Fig. 31 – Swing the pen across the cha to check for proper inking. Make sure p point is at right angles to the chart. N the measuring element, chronograph pen etc. can be connected (see connecti diagrams) and the instrument is ready for

THE ESTERLINE-ANGUS COMPANY, INC.

Pioneers in the Manufacture of Graphic Instruments

P. O. BOX 596, INDIANAPOLIS 6, INDIANA

IS 20, 10M
MAY 1957

PRINTED IN U. S

THE ESTERLINE - ANGUS CO., INC.

INDIANAPOLIS, INDIANA U.S.A.

SYNCHRONOUS CHART DRIVE ASSEMBLY.

SERIES No. 90.

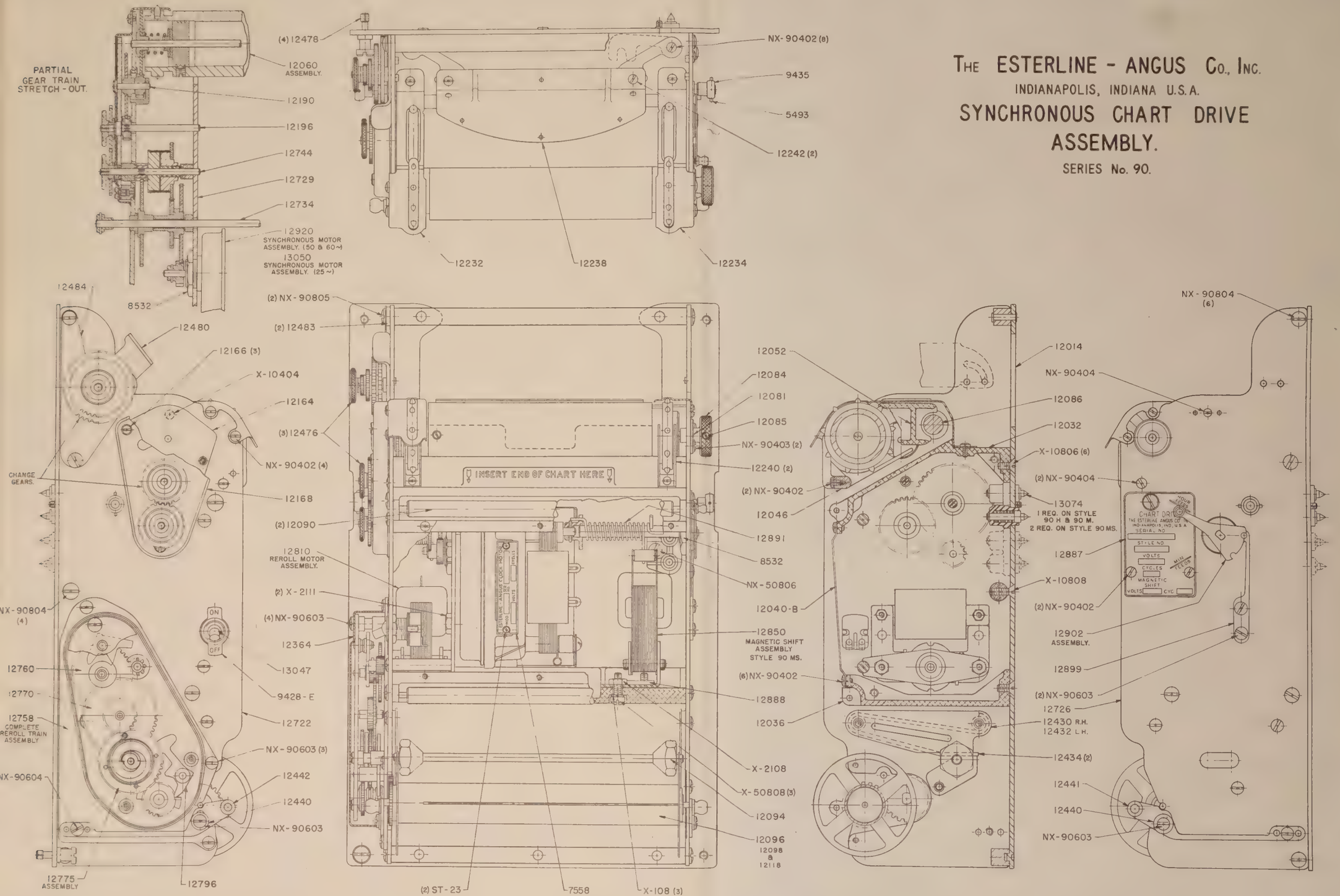
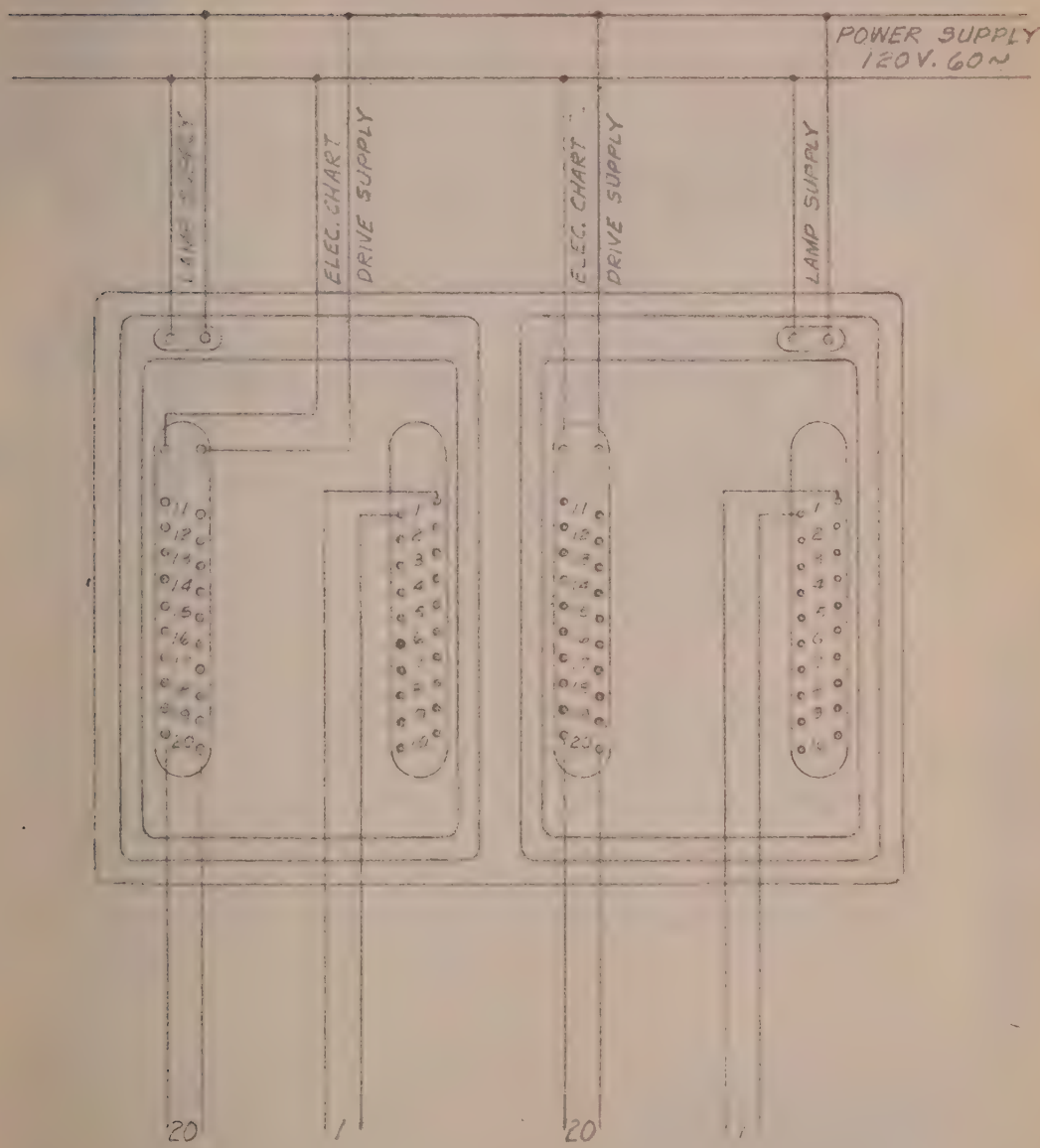


DIAGRAM OF CONNECTIONS FOR MODEL AWT-D ESTERLINE-ANGUS FLUSH TYPE 40 PEN OPERATION RECORDER WITH SEPARATE CIRCUITS, AND ELECTRIC CHART DRIVES.

BACK VIEW.



TWIN RECORDERS SCALED 1 TO 40 PENS.

NOTE - ON D.C. CIRCUITS CONNECT OUTSIDE COLUMNS OF TERMINALS ON EACH RECORDER, SHOWN IN BACK VIEW, TO THE SAME POLARITY.

CHARTS

and

Writing System Supplies

for all models of

ESTERLINE-ANGUS Graphic Instruments

The finest recorders, with the most accurate measuring elements and precision chart drives are rendered useless unless the vital combination of charts, ink and writing system is equally well engineered. Each manufacturer has worked out by diligent research the combination that works best in its particular recorder. Best performance results from using E-A charts, ink and writing system supplies in E-A recorders.

THE ESTERLINE-ANGUS COMPANY, INC.

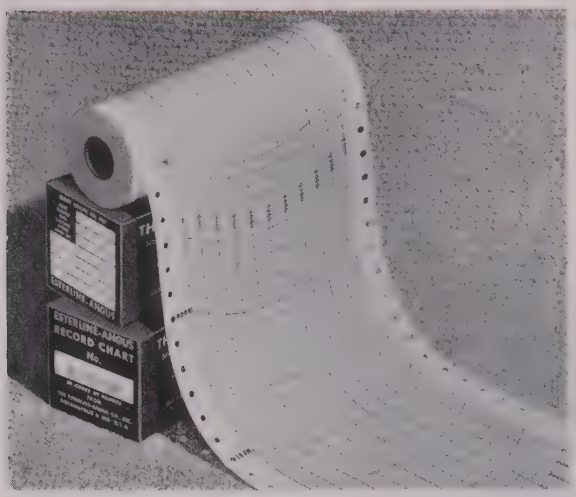
"The Meter With a Record" for Over 50 Years

P. O. BOX 596, INDIANAPOLIS 6, INDIANA

Catalog Section 90

(April 1958)

Charts for E-A Recorders



Charts are individually boxed. Packed for shipment each chart weighs about 0.6 lb.

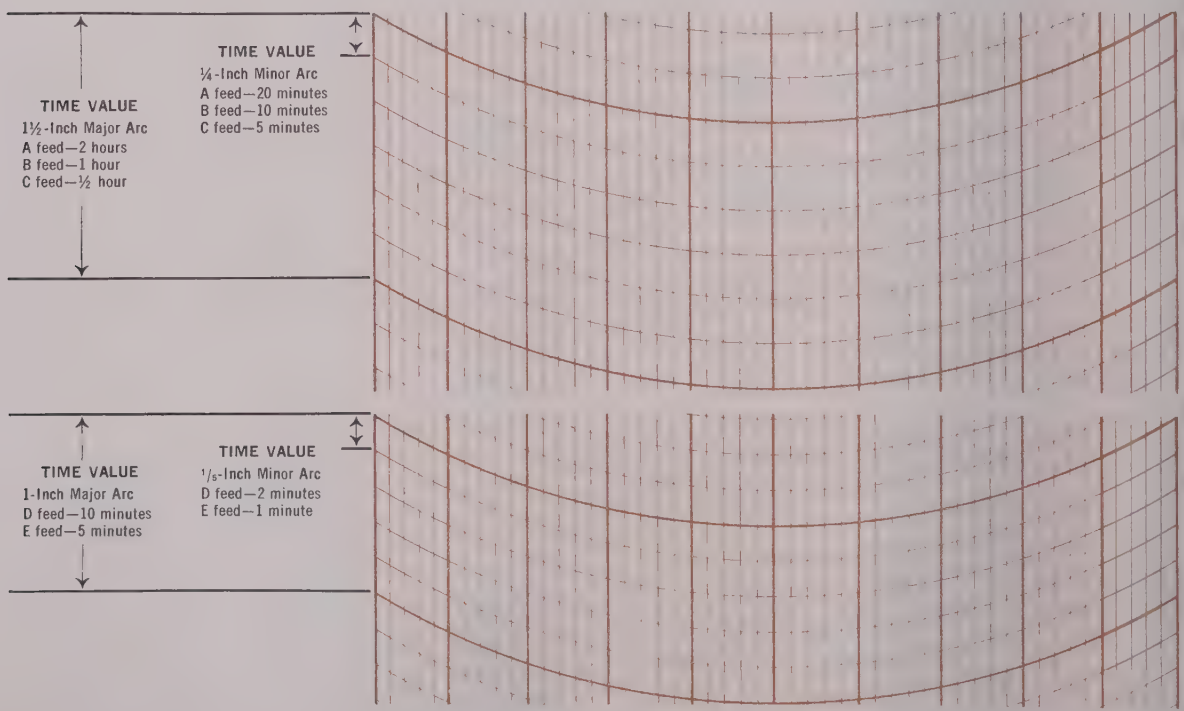
E-A record charts are of a special grade of paper, manufactured to exacting specifications, having the desired ink-absorbing qualities and the minimum change of dimensions with changes in humidity. The paper is wound on a high quality, accurately dimensioned core, which is important for proper chart feeding. The chart, ink, writing system and chart drives are parts of the composite recorder, all engineered as a major unit. To insure accuracy and continuity of records, use only E-A charts and ink in E-A recorders.

All standard charts are printed in two colors of special ink which does not interfere with the record being drawn by the recorder pen. Longitudinal rulings and arc or cross lines are in brown ink, with all other printing, such as range numbers and time numbers, in contrasting blue. The time values of the two standard arc spacings are illustrated below.

Special equipment has been designed and built for the production of charts. The paper is manufactured in quantity, shipped to our plant and thoroughly seasoned before it is printed. The chart with its record can be preserved for years, without appreciable deterioration.

Dimensions

All charts are 6 inches wide and have perforations along each edge at ½-inch intervals. The ruled portion of standard charts extends over a width of 4½ inches. Each chart is 103 feet long, the useful length being 100 feet; three feet are allowed for threading up the recorder. Range numbers are printed across the chart every 9 inches, and the time numbers along the left-hand margin at intervals of 3 or 6 inches.



Designation of Charts

Each different range, ruling and speed of chart is designated by a number which is a combination of several figures and a letter (e.g., 1310-A, 43192C).

Special Charts

We print special charts to meet the requirements of individual customers, special applications, or special meters. In many cases, a customer's requirements can be fulfilled by an unlisted chart for which we have tools available. We will gladly send samples of such charts, and will also quote on any special charts printable on our machinery (this requires that the chart be 6 inches wide and have our standard perforations) on receipt of full details of the chart design.

SUFFIX LETTER AND MINIMUM RUNNING TIME

Suffix Letter	Speed In. Per Hr.	Feet Used Per Day	Feet Used Per Week	Minimum Running Time in Days
A	¾	1½	10½	65⅔
B	1½	3	21	32⅓
C	3	6	42	15⅔
D	6	12	84	7⅓
E	12	24	168	3⅔

Speed Inches Per Min.	Feet Used Per Hour	Feet Used Per Day	Minimum Running Time in Hrs.
¾	3¾	90	26⅔
1½	7½	180	13⅓
3	15	360	6⅔
6	30	720	3⅓
12	60	1440	1⅔

At ¾, 1½ and 3 inches per second, one chart lasts 26⅔, 13⅓ and 6⅔ minutes respectively.

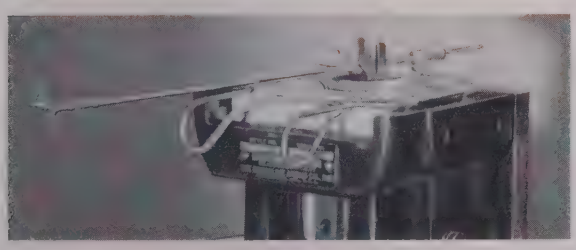
The E-A Direct-Writing Mechanism

Esterline-Angus pioneered the direct-writing system for graphic instruments. A mechanism in which the pen is operated directly by the measuring element has many distinct advantages. The E-A direct-writing system consists of two simple, removable parts: a refillable inkwell, and a pen element carried in a fork mounted on the staff of the measuring element.

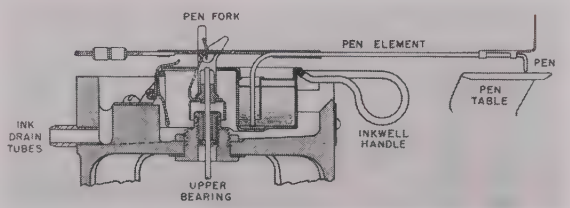
The pen element and inkwell can be inserted and removed without the use of tools or danger of disturbing any accurately aligned parts. Complete access to the writing system is provided, without tilting or swinging the chart drive out of the way.

The Inkwell

The inkwell is held securely in place in the cavity in the measuring element top assembly. The body and cover are electro-tinned drawn brass stampings to which the ink does not adhere. The cover is removable for cleaning. The opening in the cover is surrounded by a baffle which extends almost to the bottom of the inkwell. The cover opening is large enough to permit free movement of the pen element, yet is small enough to minimize evaporation.



A cavity in the top of the measuring element holds the inkwell



Cross-sectioned view of the measuring element top shows the inkwell and pen element in place, drain tubes that prevent spilled ink from reaching any current-carrying parts, as well as the canopy shielding the upper bearing

The Pen Element

The silver pen tube is fitted with knife-edges which rest in the pen fork carried by the armature staff. One end of the pen tube dips into the inkwell through the narrow cover opening. Ink flows through the tube by capillary action to the pen point at the other end of the pen tube. The pen point is finished with a fine smooth tip, to draw a narrow uniform line on the record chart. The pen element is easily lifted out without the use of tools. Adjustable weights on the pen element permit balancing, which should be done with the pen full of ink.

Ink

The manufacture of a superior ink for direct-writing recorders is not a simple problem, because the requirements are so conflicting. The ink must not evaporate readily in the inkwell, yet the inked record on the chart paper must dry quickly. It must not leave an insoluble residue in the inkwell which will clog the pen and it must not be corrosive to the inkwell or pen tube.

Continuous research and control of the manufacturing process enable E-A ink to meet these stringent requirements. It is supplied in two colors, red or green, which can be mixed to form a third color.

Ordering Charts

Charts should always be ordered by number, being careful to include the suffix letter which designates the speed. If in doubt, refer to the last chart taken from the meter.

If a permanently-installed meter must have a scale which does not correspond to a standard chart, usually a chart of some different range can be employed, together with an appropriate multiplying factor. On portable meters, and other meters having odd or multiple ranges, it is usually most convenient to use a chart with a range of 0-1 or 0-100, and then multiply the chart readings by the "constant."

Charts with ¼- or ⅛-inch arc spacing can be furnished without time numbers, the suffix letters being "X" and "V" respectively. Most such charts are not stocked and must be ordered 24 or more at a time. Such charts are used on intermittently-operated meters, or meters running only at minute or second speeds.

Blank 1000-X Charts

For special purposes, some users prefer a blank perforated chart having no printing in the recording area. Such paper is designated by the number 1000-X.

Stock Charts

Over 800 types of charts are in stock at our factory at all times, and most chart orders can be filled within two working days after receipt of order. The feeds of each chart carried in stock are shown opposite each chart listing.

It is impractical to carry in stock every possible combination of ruling, range and speed. On infrequently-ordered combinations not carried in stock we request that a minimum of 24 charts be ordered. Where this quantity is more than needed, we recommend substituting a suitable stock chart, obtainable without minimum quantity restriction.

4300 SERIES

Charts for Model AW, LR, MS and EB DC Ammeters, DC Milliammeter, DC Voltmeters, Speed, Pressure, KVA, Rectifier AC-DC Ammeters and Voltmeters, and Model AW Wattmeters and KVAR Meters.

Uniform ruling along the arc. Ruled portion of charts shown actual size. Typical range numbers are illustrated for each ruling.

10-50 Ruling. 10 Large, 50 Small Divisions.

Left-hand Zero

0	1	2	3	4	5	6	7	8	9	10
0	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25
0	5	10	15	20	25	30	35	40	45	50
0	12.5	25	37.5	50	62.5	75	87.5	100	112.5	125

Center Zero

5	4	3	2	1	0	1	2	3	4	5
10	8	6	4	2	0	2	4	6	8	10
25	20	15	10	5	0	5	10	15	20	25
125	100	75	50	25	0	25	50	75	100	125

15-75 Ruling. 15 Large, 75 Small Divisions.

Left-hand Zero Only

0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	1.1	1.2	1.3	1.4	1.5
0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5

LEFT-HAND ZERO

Chart Number†	Chart Range	Ruling	Stock Feeds*
4300	No Range Nos.	10–50	A/B/C/D/E/X
4302	No Range Nos.	15–75	A/B/C/D/X
43022	No Range Nos.	18–90	D
4303	No Range Nos.	8–40	A/B/C/X
4304	No Range Nos.	12–60	C/D/E/X
4305	0–1	10–50	A/B/C/D/E/V/X
43052	0–1.5	15–75	A/C/X
4306	0–2	8–40	A/B/C/X
43061	0–2.5	10–50	C
43062	0–3	12–60	A/B/C/D
43065	0–4	8–40	C
4309	0–5	10–50	A/B/C/D/E/X
43091	0–6	12–60	A/B/C
43092	0–7.5	15–75	C
4310	0–10	10–50	A/B/C/D/E/X
43102	0–15	15–75	A/B/C/D/E/X
43105	0–20	8–40	A/B/C/E/X
4311	0–25	10–50	A/B/C/D/X
43112	0–30	12–60	A/B/C/D/X
43115	0–40	8–40	A/B/C/E/X
4312	0–50	10–50	A/B/C/D/E/X
43121	0–60	12–60	A/B/C/D/X
43122	0–75	15–75	A/B/C/D/E/X
43125	0–80	8–40	A/B/C
4313	0–100	10–50	A/B/C/D/E/X
43131	0–120	12–60	A/B/C/D/E/X

*If desired feed is not shown as Stock, order at least 24.

†Select the correct chart number, corresponding to the range numbers desired and ADD the proper speed designating letter. See page 3.

4300 Series, *Continued*

Chart Number†	Chart Range	Ruling	Stock Feeds*
43135	0–125	10–50	A/B/C
4314	0–150	15–75	A/B/C/D/E/X
43141	0–160	8–40	B/C
4315	0–200	8–40	A/B/C/D/E/X
4316	0–250	10–50	A/B/C/D/E/X
4317	0–300	12–60	A/B/C/D/E/X
4318	0–400	8–40	A/B/C/D/E/X
4319	0–500	10–50	A/B/C/D/E/X
43192	0–600	12–60	A/B/C/D/E/X
4320	0–750	15–75	A/B/C/X
43202	0–800	8–40	A/B/C/D/E/X
4321	0–1000	10–50	A/B/C/D/E/X
43212	0–1200	12–60	A/B/C/D/X
4322	0–1500	15–75	A/B/C/D/E/X
43222	0–1600	8–40	A/B/C/X
43225	0–1800	18–90	C/X
4323	0–2000	8–40	A/B/C/D/E/X
43231	0–2400	12–60	A/B/C
43232	0–2500	10–50	A/B/C/X
4324	0–3000	12–60	A/B/C/D/E/X
43242	0–4000	8–40	A/B/C/D/E/X
43245	0–4500	18–90	B/C
4325	0–5000	10–50	A/B/C/D/X
43252	0–6000	12–60	A/B/C/D/E
4326	0–7500	15–75	B/C
43262	0–8000	8–40	A/B/C
4327	0–10000	10–50	A/B/C/D/E/X
43272	0–12000	12–60	A/B/C
4328	0–15000	15–75	A/B/C/X
4329	0–20000	8–40	A/B/C
4330	0–25000	10–50	C
43302	0–30000	12–60	B/C

CENTER ZERO

43042	No Range Nos.	15–30	X
43311	0.5–0–0.5	10–50	C/X
43315	1–0–1	10–50	X
4362	2.5–0–2.5	10–50	A/C/D/X
4331	5–0–5	10–50	A/B/C/D/E/X
4332	10–0–10	10–50	A/B/C/D/E/X
43312	12–0–12	12–60	B/C
43321	15–0–15	12–60	A/B/C/D/X
43322	20–0–20	8–40	A/B/C/X
4361	25–0–25	10–50	A/C/D/E/X
4334	30–0–30	12–60	A/B/C/X
43342	40–0–40	8–40	A/B/C
4346	50–0–50	10–50	A/B/C/X
4347	60–0–60	12–60	A/B/C/X
4335	75–0–75	15–30	A/B/C
4363	80–0–80	8–40	A/B/C/X
43351	90–0–90	18–90	D
4333	100–0–100	10–50	A/B/C/D/X
43362	125–0–125	10–50	C/D
43352	150–0–150	12–60	A/B/C/E/X
4337	200–0–200	8–40	A/C/D/E
43331	250–0–250	10–50	C
4343	300–0–300	12–60	B/C
43432	400–0–400	8–40	C
4344	500–0–500	10–50	C/D/X
4340	600–0–600	12–60	C/D
4336	750–0–750	15–30	C/D
4341	800–0–800	8–40	C/D
4345	1000–0–1000	10–50	B/C/D/E/X
43452	1500–0–1500	12–60	C
4350	2000–0–2000	8–40	B/C
43502	2500–0–2500	10–50	C
43512	3000–0–3000	12–60	C/D
4352	4000–0–4000	8–40	A/B/C/E
43521	5000–0–5000	10–50	A/B C, D
43522	6000–0–6000	12–60	A/C
4353	8000–0–8000	8–40	A/C/X
43332	10000 0 10000	10–50	C

*If desired feed is not shown as Stock, order at least 24.

8-40 Ruling. 8 Large, 40 Small Divisions.

Left-hand Zero

0	.25	.5	.75	1.0	1.25	1.5	1.75	2.0
0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
0	10	20	30	40	50	60	70	80
0	20	40	60	80	100	120	140	160

Center Zero

20	15	10	5	0	5	10	15	20
40	30	20	10	0	10	20	30	40
80	60	40	20	0	20	40	60	80

12-60 Ruling. 12 Large, 60 Small Divisions.

Left-hand Zero

0	.25	.5	.75	1.0	1.25	1.5	1.75	2.0	2.25	2.5	2.75	3.0
0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
0	10	20	30	40	50	60	70	80	90	100	110	120
0	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400

Center Zero

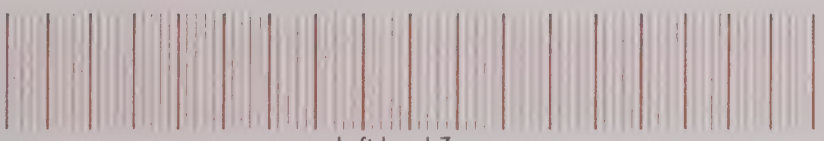
12	10	8	6	4	2	0	2	4	6	8	10	12
30	25	20	15	10	5	0	5	10	15	20	25	30
60	50	40	30	20	10	0	10	20	30	40	50	60
150	125	100	75	50	25	0	25	50	75	100	125	150

15-30 Ruling. 15 Large, 30 Small Divisions.

Center Zero Only

75	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	75

18-90 Ruling. 18 Large, 90 Small Divisions.



Left-hand Zero

0	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800

Center Zero

90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90

†Select the correct chart number, corresponding to the range numbers desired and ADD the proper speed designating letter. See page 3.

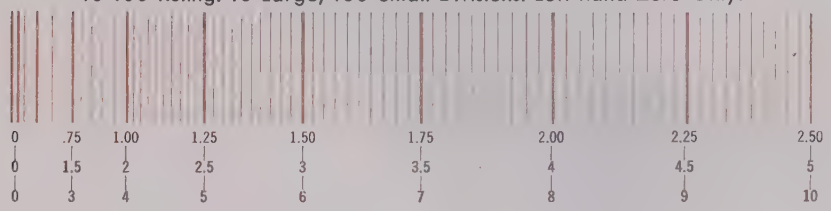
1300 SERIES

Charts for all Models of Dynamometer Type, AC Ammeters and AC and AC-DC (Utility) Voltmeters.

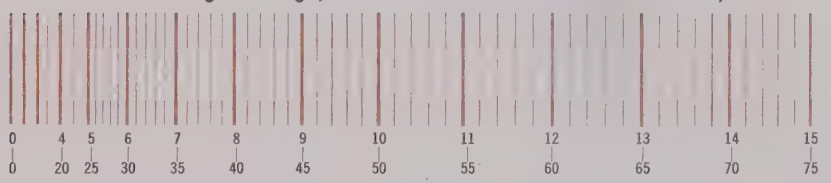
Approximately quadratic ruling. Ruled portion of charts shown actual size.

Due to the quadratic characteristics of these chart scales, it is not feasible to include in the extreme lefthand portions (below approximately 10-15% of the scale width) the full number of large and small division ruling lines. *Typical range numbers are illustrated for each ruling.*

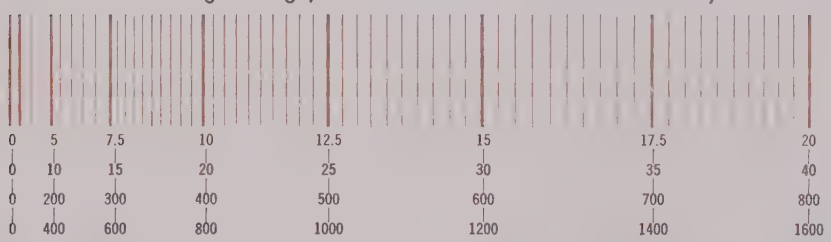
10-100 Ruling. 10 Large, 100 Small Divisions. Left-hand Zero Only.



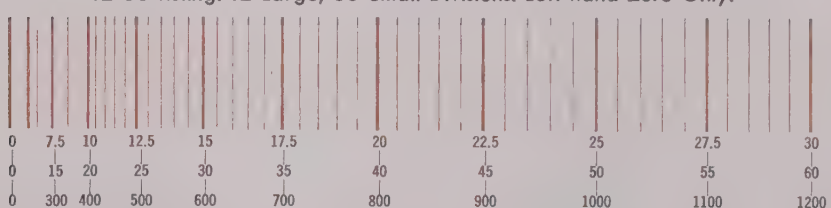
15-75 Ruling. 15 Large, 75 Small Divisions. Left-hand Zero Only.



8-80 Ruling. 8 Large, 80 Small Divisions. Left-hand Zero Only.



12-60 Ruling. 12 Large, 60 Small Divisions. Left-hand Zero Only.



9-90 Ruling. 9 Large, 90 Small Divisions. Left-hand Zero Only.

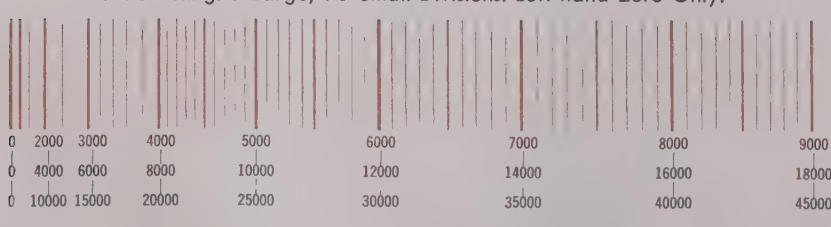


Chart Number†	Chart Range	Ruling	Stock Feeds*
1300	No Range Nos.	10–100	C/X
1301	No Range Nos.	15– 75	C/X
1302	No Range Nos.	8– 80	—
1303	No Range Nos.	12– 60	X
1304	No Range Nos.	9– 90	-
1307	0–2.5	10 100	C/D/X
1310	0 5	10 100	A/B/C/D/E/X
1311	0–10	10–100	A/B/C/D/X
1312	0–15	15– 75	B/C/D/X
13122	0–20	8– 80	C/X
1313	0–25	10–100	A/B/C
13132	0–30	12– 60	A/B/C
13135	0–40	8– 80	—
1314	0–50	10–100	A/B/C/D/E/X
13141	0–60	12– 60	B/C
13142	0–75	15– 75	A/B/C/X
1315	0–100	10–100	A/B/C/D/E
1316	0–150	15– 75	A/B/C/D/E/X
1317	0–200	8 80	A/B/C/D/E
1318	0 250	10–100	B/C
1319	0 300	12– 60	A/B/C/D/E/X
13192	0–400	8 - 80	B/C
1320	0–500	10–100	B/C/X
13202	0–600	12– 60	A/B/C/X
1321	0–750	15– 75	B/C
1334	0–800	8– 80	A/C/X
1322	0–1000	10–100	C/X
13222	0–1200	12– 60	C
1323	0–1500	15– 75	C
13231	0–1600	8– 80	C
1324	0–2000	8– 80	A/B/C
13242	0–2500	10–100	
1325	0–3000	12– 60	A/B/C
1326	0–4000	8– 80	B/C
1327	0–5000	10–100	B/C
13272	0–6000	12– 60	A/B/C
1328	0–7500	15– 75	C/X
1337	0–9000	9– 90	A/B/C/D
1329	0–10000	10–100	A/C
1330	0–15000	15– 75	A/B/C
13302	0–18000	9– 90	A/B/C
1331	0–20000	8– 80	B
1339	0–45000	9– 90	A/B/C
1333	0–50000	10 100	
1341	0–90000	9– 90	A/B/C
1345	0–180000	9– 90	B

†Select the correct chart number, corresponding to the rang numbers desired and ADD the proper speed designating lette See Page 3.

*If desired feed is not shown as Stock, order at least 24.

1700 SERIES

Operation Recorders

Chart Number†	Pen Position Numbers	Stock Feeds*
1700	None	B/C/D/E/V/X
1705	1–5	A/B/C/D/E/X
1710	1–10	A/B/C/D/E/X
1720	1–20	A/B/C/D/E/V/X
1740	21–40	A/B/C/D/E/X
1760	41–60	A/B/C/D/X
1780	61–80	B/C/D
17100	81–100	——
17120	101–120	——
17140	121–140	——
17160	141–160	——

Chart Number†	Chart Range	Ruling	Stock Feeds*

1500 SERIES

Frequency

1515	55–65 cycles	10–50	A/B/C/D/X
1550	45–55 cycles	10–50	C/D
1520	20–30 cycles	10–50	B/C
1552	45–65 cycles	10–40	C
15522	46–66 cycles	10–40	B/C

1400 SERIES

Power Factor

1407	.50–1.00–.70	8–18	A/B/C/D
1403	.40–1.00	6–13	C

1600 SERIES

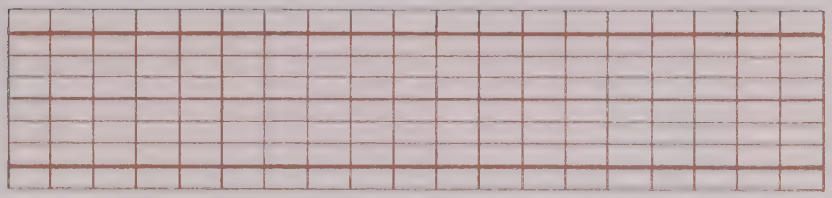
Conductivity (Not Illustrated)

1600	0–3000	15–30	B
1605	0–infinity	18 61	A/B

2300 SERIES

Used only for Model LR, MS and EB Kvar and Wattmeters. Not for Model AW Meters. These rulings not illustrated.

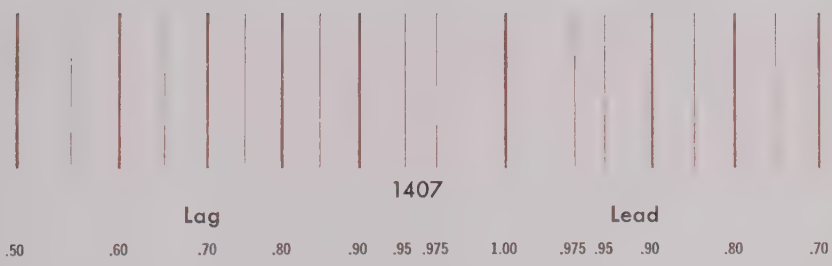
Ruled portion of charts shown actual size.



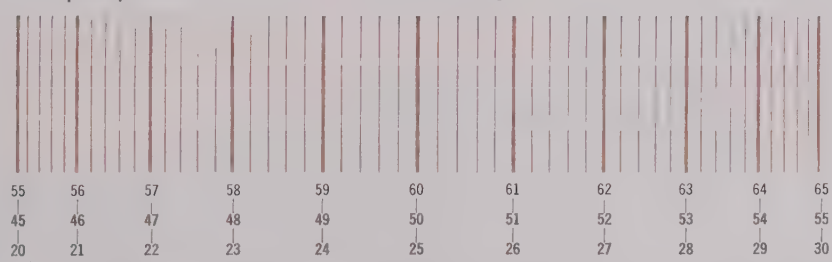
Operation Recorders (1700 series) 1/8″ cross lines, A, B and V feeds.

Operation Recorders (1700 series) 1/10″ cross lines, C, D, E and X feeds.

Power Factor Recorders (1400 series)



Frequency Recorders (1500 series) 10-50 Ruling. 10 Large, 50 Small Divisions.



†Select the correct chart number, corresponding to the range numbers desired and ADD the proper speed designating letter. See page 3.

*If desired feed is not shown as Stock, order at least 24.

Chart Number†	Chart Range	Ruling	Stock Feeds*
2302	No Range Nos.	10–50	E
2310	0–1	10–50	A/B/C
23102	0–2	8–40	A/C
2312	0–5	10–50	C
2313	0–10	10–50	C
2314	0–15	15–30	A/C
23142	0–20	8–40	C
2315	0–25	10–50	C
2316	0–50	10–50	B
2317	0–75	15–30	B
2318	0–100	10–50	B
23182	0–120	12–60	C
2319	0–150	15–30	A/C
23192	0–160	8–40	A
2320	0–200	8–40	B/C

Chart Number†	Chart Range	Ruling	Stock Feeds*
2321	0–250	10–50	A
2322	0–300	15–30	A/C
2323	0–400	8–40	A/B
23232	0–450	15–30	B
2324	0–500	10–50	B/C
23242	0–600	12–60	B/C
2325	0–750	15–30	B
23252	0–800	8–40	B/C
2326	0–1000	10–50	B/C
23262	0–1200	12–60	B/C
2327	0–1500	15–30	B/C
23272	0–1600	8–40	A/C
2328	0–2000	8–40	A/B/C
23282	0–2400	12–60	B/C
2329	0–2500	10–50	C

Chart Number†	Chart Range	Ruling	Stock Feeds*
2330	0–3000	15–30	B/C
2331	0–4000	8–40	B/C
2332	0–5000	10–50	B/C
23322	0–6000	12–60	B/C
2333	0–7500	15–30	C
23332	0–8000	8–40	C
2334	0–10000	10–50	C
23342	0–12000	12–60	C
2335	0–15000	15–30	C

CENTER ZERO

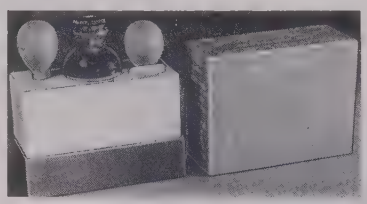
2336	100–0–100	10–40	A/B/C
2346	1200–0–1200	10–40	C
23372	8000–0–8000	10–40	A/B

Writing System Parts and Supplies

Ink

Recorder ink, especially prepared for use in the E-A writing system is available in red or green color in 2-ounce, 1 pint and gallon bottles.

Accessory Kit



The AW Accessory Kit is housed in a cardboard box as shown above. Each kit contains a 2-ounce bottle of ink, pen filler, inkwell filler and pen point cleaner.

Pen Point Cleaner

Pen Filler

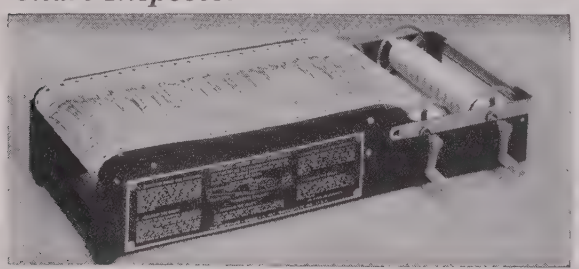
Inkwell Filler

Pen point cleaner, pen filler and inkwell filler can be purchased separately or in the kit, above.

Pen Points

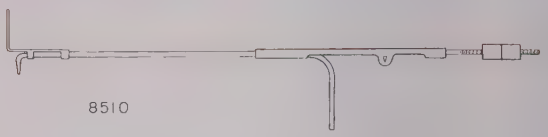
No. 82-M—Replaceable pen points. These are illustrated in pen elements 8510, 9056, 9892 and 9112 in the next column.

Chart Inspector



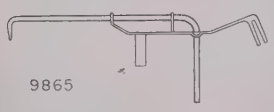
The chart inspector is a convenient tool for inspecting records, making notes on them and re-rolling them for filing. It is shipped complete with two cranks.

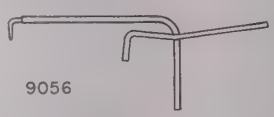
Pen Elements



No. 8510—AW Standard pen element for ammeters, milliammeters, voltmeters, wattmeters, etc. 6 5/16" long over-all.

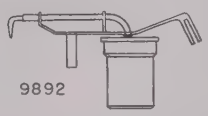
No. 3154—LR-MS Standard pen element, 5 7/8" long over-all. (Not illustrated but similar to No. 8510)





No. 9865—One-piece, for AW operation recorders above serial No. 30782 (supersedes 9856 which had a replaceable pen point).

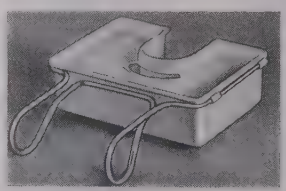
No. 9056—For AW operation recorders below serial No. 30782.



No. 9892—AW chronograph pen element and inkwell assembly. Give serial number.

No. 9112—AW chronograph pen element and inkwell assembly. Give serial number.

Inkwells



No. 8516—AW Standard inkwell with cover.

No. 4038—(Not illustrated)—LR Standard inkwell with cover.

No. 9849—Inkwell with stainless steel body, for AW operation recorders above serial No. 30782.

No. 9050—For AW operation recorders below serial No. 30782. (Not illustrated)

THE ESTERLINE-ANGUS COMPANY, INC.

Pioneers in the Manufacture of Graphic Instruments

P. O. BOX 596, INDIANAPOLIS 6, INDIANA

Catalog Section 90
Printed in U.S.A., 20M

Product Representatives in Most Principal Cities

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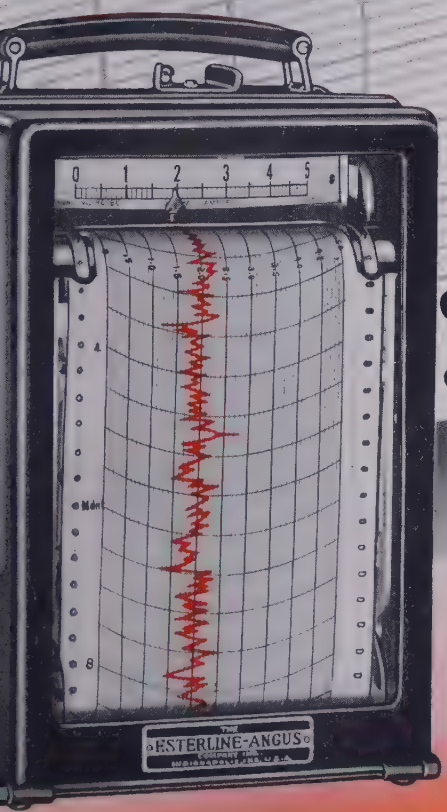
TH A RECORD"

THE ESTERLINE-ANGUS CO., INC., INDIANAPOLIS, IND., U.S.A.



THERE IS AN

ESTERLINE-ANGUS GRAPHIC INSTRUMENT

to get the facts you want

CATALOG NO. 657

GRAPHIC RECORDERS

Modern civilization depends heavily on measurement. The development of measuring instruments had a tremendous influence upon the improvement of existing equipment, and the development of new devices and processes. Railroads, electric utilities, radio stations and other communication facilities, steel mills, chemical works, automotive and aircraft plants, airlines, scientific and medical research laboratories, government research and experimental installations, national defense installations, all have a basic similarity in that they use measuring instruments to obtain accurate and unbiased information.

Measuring devices secure the facts which lead to better service, new and better products, greater safety, and more economical operation. *Recording* instruments are especially important in our modern economy because they gather information automatically and continuously without requiring the presence of a human operator.

Operating Conditions

Recording instruments are required to operate under every conceivable condition. They are used in damp places; in atmospheres laden with metallic dust; in the presence of fumes and gases; in vehicles and in aircraft. Such operating conditions call for excellence in design, workmanship and materials.

Many recording instruments are in service twenty-four hours a day, every day in the year. Recorders

FIG. 1—*Here are 3 of 11 Operation Recorders which tally production of 18,000 automobile inner tubes per day. (Goodyear Tire and Rubber Co. photo)*

FIG. 2—*An Esterline-Angus Recording Milliammeter housed in a portable case. The chart is 6 inches wide with an active width of 4½ inches.*

are frequently part of a permanent installation which is expected to last for many years, and they should, therefore, have a life comparable with the heavy apparatus with which they are used.

As processes change with new developments, it is desirable that it be possible to change instrument characteristics with a minimum of expense to handle the new conditions.

All of these conditions call for instruments with the maximum practical accuracy and flexibility along with the ruggedness and simplicity which result in low maintenance cost.

50 Years of Instrument Design

The present design of Esterline-Angus recording instruments is the culmination of 50 years of experience in this highly specialized field. We have built to meet the demand of those purchasers who want the best—as measured by a high standard of performance and a low cost per unit of satisfactory service.

On the following pages are some of the more pertinent details concerning "The Meter With a Record." If you wish additional information or a quotation, one of our many qualified product representatives is at your service.

ELECTRODYNAMOMETER MEASURING ELEMENTS

For measuring current, voltage, vars, power factor and frequency in AC circuits, and power in either AC or DC circuits, electrodynamometer measuring elements are normally used. These usually consist of two coil groups: fixed field coils, and movable armature coils. Rotation of the movable coils is the result of torque produced by interaction of the magnetic fields created when current is flowing through both sets of coils. Rotation is usually opposed by "torque" springs, which also determine the zero position when the instrument is not energized.

Direct Writing

The writing pen, attached to the moving system, is an ink-on-paper type, requiring no relays, balancing circuits, linkages or servo systems for its operation.

All Esterline-Angus dynamometer instruments are basically of the 2-element type. The two movable coils are mounted on a single staff which rotates within the two sets of stationary coils. This makes possible an astatic movement—one in which the effect of a uniform external magnetic field (such as the earth's field) is nullified, and hence eliminates a possible source of error.

Elements Are Interchangeable

Final assembly of a measuring element includes completing all electrical connections to terminal boards, which become an integral part of the element. The element is thus a complete working unit, which can be installed in or removed from the case without disturbing any of the connections. Careful attention was given to the design of this unit assembly to permit transfer or interchange of measuring elements in the various types of Esterline-Angus cases. Thus it is possible to replace one type of dynamometer element with another or to interchange a dynamometer measuring element with a permanent-magnet moving-coil element without modification of any component. Replacement of an electrical element with one measuring pressure or position is also possible, but in certain instances requires a minor modification of the case.

Stable Characteristics

Sustained accuracy of an instrument depends upon every part retaining its original position and shape, independent of age, temperature or mechanical shock. All Esterline-Angus electrodynamometer recorders have measuring element parts mounted on a single heavy, rigid bakelite frame, which not only has excellent physical stability, but also insures a high insulation value—several times that commonly found in other makes.

Protection from Ink

In the design of this element, care has been taken to prevent spilled ink from reaching any of the electrical windings. The upper bearing support is protected so that ink cannot flow down around it; the staff carries a canopy which prevents spilled ink from reaching the bearing. A drain is provided to carry away excessive spillage from the recess in which the inkwell rests.

Adjustable Damping

The damping is magnetic, accomplished by an aluminum disc which swings across the poles of Alnico magnets secured to the bottom of the bakelite frame. In each type of measuring element, the damping is properly proportioned to the inertia and torque of the moving system, and is adjustable over a considerable range.

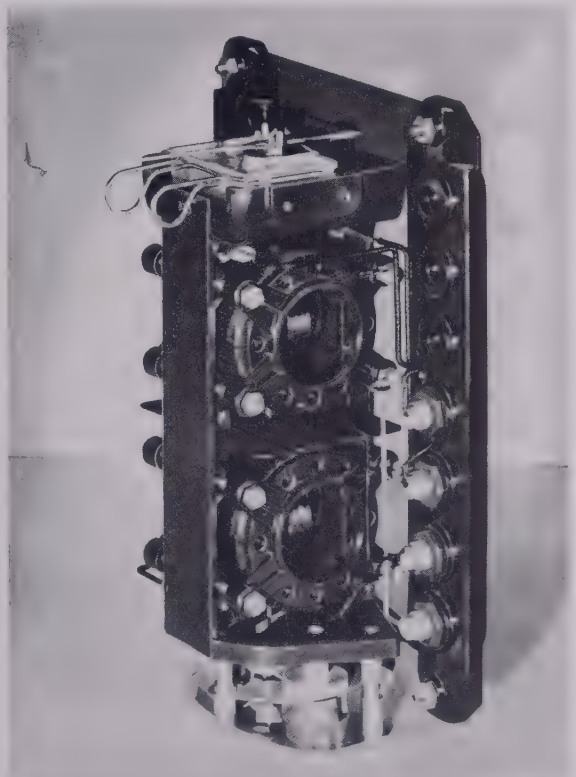


FIG. 3—*The electrodynamometer measuring element used in Esterline-Angus AC instruments. Note the rigid molded bakelite frame which maintains all parts in accurate alignment.*

FIG. 4—*An Esterline-Angus recorder showing the load on a sand muller. The record helps the operator to mix ingredients consistently.*

AC AMMETERS (Catalog Section 30)

Ampere Range	Burden in VA 60 Cycles	Frequency Limits for 1% Accuracy (Cycles)
0-5	9.5	25-400
0-7.5	15.0	25-240
0-10	9.5	25-400
0-15	15.0	25-240
0-20	9.5	25-400
0-5/10	9.5	25-400

For ranges below 0-5 amperes, the rectifier type instrument (Catalog Section 48) is recommended.

Response time is approximately 1.15 seconds. Accuracy is 1% of full scale current. Portable meters have 5-foot leads. AC ammeters have left hand zero only.

When operated on circuits above 800 volts, a current transformer must be used.

AC WATTMETERS (Catalog Section 33)

(2-element)

Nominal ratings of 5-ampere instruments:

Kilowatts (Self-Contained)	Volts	
1.0	100	Burdens at 60 cycles:
2.0	200	
5.0	500	Each current circuit
1.0/2.0	100/200	9.5 VA.
1.0/5.0	100/500	Each 100 Volt potential circuit at 120 volts, 6.3 VA.
2.0/5.0	200/500	
1.0/2.0/5.0	100/200/500	

2-element AC wattmeters are primarily for use on single-phase 2- and 3-wire; 2-phase 3-, 4- and 5-wire; and 3-phase 3-wire circuits. Standard frequencies are 25 to 60 cycles, special instruments being available for 400 cycles.

Response time is approximately 1¼ seconds. Accuracy is 1% of full scale watts. Portable meters have 5-foot current and potential leads. AC wattmeters can have zero at any point between the left hand side and center of scale.

AC WATTMETERS (Catalog Section 33)

(3-current and 4-current-element)

Nominal ratings of 5-ampere instruments:

Kilowatts (Self-contained) 3-current-element	4-current-element	Volts
1.5	1.0	100
3.0	2.0	200
7.5	5.0	500

The burden of each current circuit does not exceed 3 VA at 5 amperes, 60 cycles. The burden of each potential circuit does not exceed 6 VA at 120 volts, 60 cycles.

3-current-element wattmeters are for use primarily on 3-phase 4-wire star-connected circuits. Standard frequencies are 25 to 60 cycles, special instruments being available for 400 cycles.

4-current-element wattmeters are for use on any single phase, 2-phase, or 3-phase circuit, including 3-phase, 4-wire delta-connected circuits for combined lighting and power.

Response time is approximately 1 second. Accuracy is 1% of full scale watts. Portable meters have 5-foot current and potential leads. The zero can be at any point between the left hand side and center of scale.

DC AND AC-DC (UTILITY) WATTMETERS (Catalog Section 33)

Nominal ratings:

Kilowatts (Self-contained)	Volts
1.0	100
2.0	200
5.0	500

Current circuits are rated 5 amperes, 100 MV at shunt end of leads. The burden of each current circuit does not exceed 1 VA at 5 amperes. The burden of each potential circuit does not exceed 8 VA at 120 volts.

DC wattmeters are for use on DC 2-wire or 3-wire, with 100 millivolt shunts. Utility (AC-DC) wattmeters are for use on either AC or DC.

Response time is approximately 1 second. Accuracy is 2% of full scale watts. All meters have 5-foot current leads. Portable meters also have potential leads. The zero can be at any point between the left hand side and center of the scale.

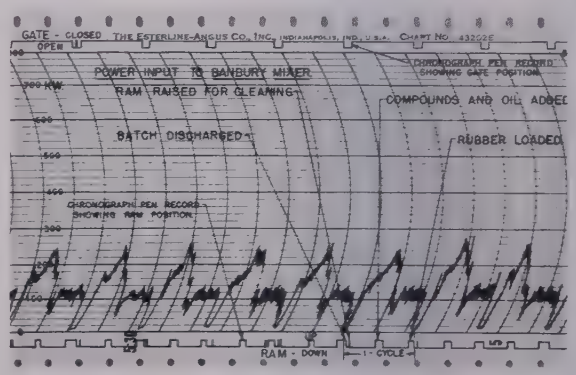


FIG. 5—*Chart showing power input to motor driving a Banbury mixer during compounding of rubber. The power required increases as compounds and oils are added. Operation of mixer ram and gate are shown by chronograph pens.*

For further information ask for the Catalog Section shown.

AC VOLTMETERS (Catalog Section 30)

Voltage Range	Full Scale Current (Amps.)	
0-50	0.38	
0-100	0.18	The burden of the 0-150 volt range at 120 volts is approximately 12.5 VA.
0-150	0.13	
0-300	0.13	
0-600	0.13	
0-750	0.13	

Combinations of most of the standard ranges between 0-50 volts and 0-750 volts AC are available The most frequent combination is 0-150/300/600 volts. Standard frequencies are 25, 50 or 60 cycles. Rectifier type recorders (Catalog Section 48) should be used for multi-frequency and for AC-DC service.

Response time is approximately 1.3 seconds. Accuracy is 1% of full scale voltage. Portable meters have 5-foot leads. AC voltmeters have left hand zero only.

POWER FACTOR RECORDERS
(Catalog Section 37)

Single and Polyphase

Nominal Rating Amperes	Volts	Current Circuit Burden at 5 amps., 60 Cycles
5	120	Polyphase—19 VA
5	240	Single Phase—19 VA
5	480	Potential Circuit Burden at 120 volts, 60 Cycles
5	120/240	
5	120/480	Polyphase—19 VA
5	240/480	Single Phase—25 VA
5	120/240/480	

Polyphase power factor recorders are for use on balanced 3-phase, 25 to 60 cycle circuits where the direction of power flow is the same at all times. Single phase recorders are for use primarily on single phase, 60 cycle circuits but can be supplied with a separate network for use on 3-phase, 3-wire, 60 cycle circuits.

Response time is approximately 1¼ second at rated voltage and current. Accuracy is 1% of the scale width on the polyphase meter and 1½% on the single phase meter, when operated with 2 amperes or more in the current circuit, and at rated voltage.

FIG. 6—*A steel mill switchboard containing 65 graphic recorders. Many of the instruments are wattmeters measuring the power input to large motors.*

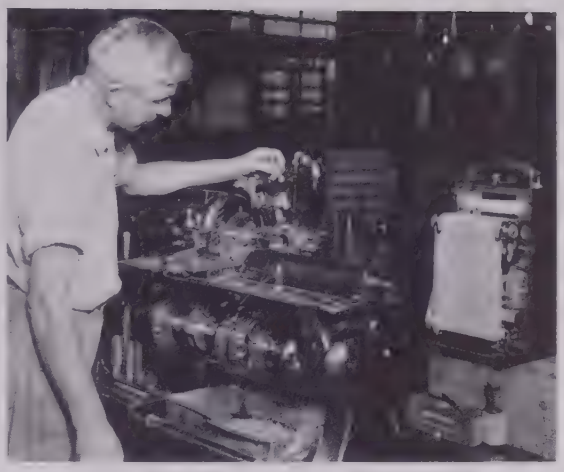


FIG. 7—*A portable wattmeter in use on an automatic screw machine. Records obtained are useful for studies of production time, coolants, speeds, tools and materials.*

FREQUENCY RECORDERS
(Catalog Section 38)

Frequency Range (Cycles Per Second)	Voltage Rating	
45-55	120	The burden is approximately 10.5 VA unity power factor, at 120 volts
55-65	120	
46-66	120	
20-30	120	

Frequency recorders can be operated continuously on voltages between 100 and 135 volts.

Response time is 1 to 2 seconds depending on range and applied voltage.

Accuracy is 2% of active scale width. (This is 0.2 cycle in the center third of a 55-65 cycle recorder.) Portable meters have 5-foot leads. Frequency recorders have no torque springs and, hence, no free zero.

KVA AND KVAR RECORDERS
(Catalog Section 35)

2- or 3-current-element

Nominal ratings (5-ampere current circuits):

KVAR OR KVA (Self-contained) 2-element	3-element	Volts
1.0	1.5	100
2.0	3.0	200
1.0/2.0	1.5/3.0	100/200

Polyphase KVA and KVAR measurements may be made on 3-phase, 3-wire circuits by using a standard 2-element wattmeter and a phase shifting network, and on 3-phase, 4-wire star circuits by using a 3-current-element wattmeter and a phase shifting network. Power flow must normally be in a single direction for KVA measurements, limiting such recorders to left hand zero. KVAR recorders may be supplied with zero at any point between the left hand side and center of scale. Some KVAR measurements can be made without the use of a network.

Response time is approximately 1¼ seconds. Accuracy is 1½% of full scale reading. Portable instruments have 5-foot leads.

For further information ask for the Catalog Section shown.

PERMANENT-MAGNET MOVING-COIL RECORDERS

Measurements of current and voltage in DC circuits are usually made with a permanent-magnet moving-coil element. This measuring element, often referred to either as the PMMC or d'Arsonval movement, employs two Alnico V magnets to produce the intense magnetic field in which the armature coil moves. The principle of motion is the same as that of an electric motor: a current-carrying conductor in a magnetic field is acted upon by a force which tends to move the conductor in a direction at right angles to the direction of the field.

The direction of the motion is reversed if the direction of the current in the conductor is reversed. The rotation of the coil is opposed by springs which return the coil to a fixed zero position when no current is flowing.

The writing pen, attached directly to the moving system, is an ink-on-paper type, requiring no relays, balancing circuits, linkages or servo systems for its operation.

All electrical connections are made to attached terminal boards when an element is placed in the instrument case. The element thus is a complete working unit and can be removed from the case without disturbing any of the connections to it. Careful attention was given to the design of this unit assembly to permit transfer or interchange of measuring elements in the various types of Esterline-Angus cases. Thus it is possible to replace one type of dynamometer element with another or to interchange a dynamometer measuring element with a permanent-magnet moving-coil element without modification of any component. Replacement of an electrical element with one measuring pressure or position is also possible, but in certain instances requires a minor modification of the case.

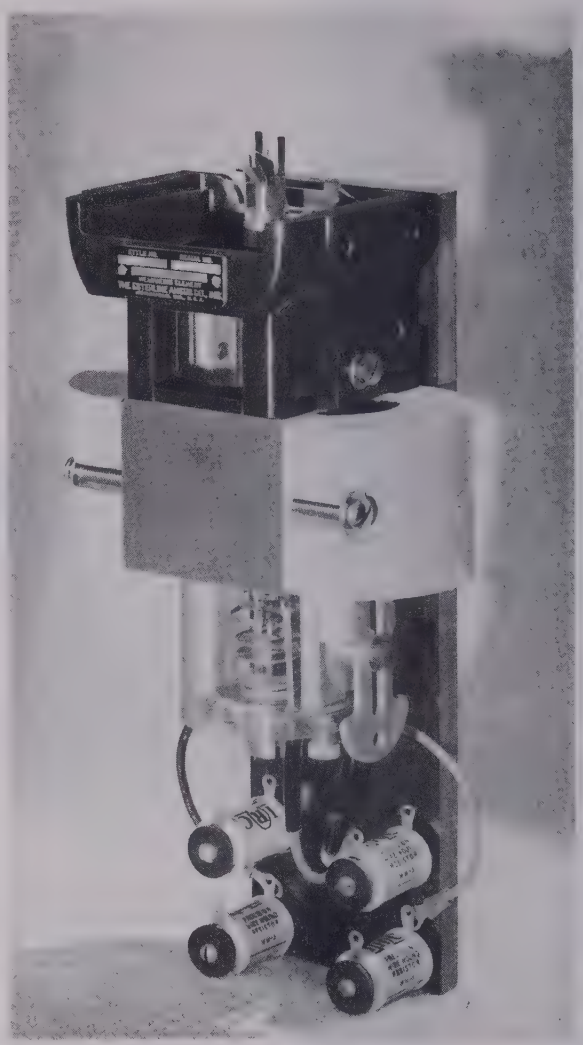


FIG. 8—*The permanent-magnet moving-coil measuring element used in Esterline-Angus DC instruments.*

Mechanism Well Protected

Protection from dust, dirt and mechanical damage is given to the internal portions of the measuring element by transparent plastic shields. With this protection, there is little possibility of dirt or magnetic particles gaining access to the air gap. This feature is important where the meter is exposed to flying scale or magnetic dust. Further protection is given the user and the instrument by the use of a bakelite plate on which the measuring element is mounted. This unit has been constructed to withstand an insulation test of 5,000 volts AC, an important feature when the instrument is used on high DC voltages.

In the design of this element, care has been taken to prevent spilled ink from reaching the armature coil. The upper bearing support is protected so that ink cannot flow down around it; the staff carries a canopy which prevents spilled ink from reaching the bearing. A drain is provided to carry away excessive spillage from the recess in which the inkwell rests.

Sensitivity and Damping

Damping of the moving element is produced chiefly by the eddy currents which flow in the metallic frame of the moving coil as it rotates in the magnetic field, and secondarily by the effect of current flow in the circuit connected to the instrument. There is no appreciable over-shooting. The sensitivity of this element makes it possible to provide DC ammeters which will come to full scale on as low as 30 millivolts, and milliammeters with the low range of 0-1 MA.

DC MILLIAMMETERS (Catalog Section 42)

Range in Milliamperes	Volts Drops at Full Scale	Resistance in Ohms
0-1	1.4	1400
0-5	0.35	70
0-10	2.0	200
0-50	2.0	40
0-100	2.0	20
0-150	0.02	0.12

Accuracy is 1% of full scale reading.

The response time of DC Milliammeters is 0.5 second, when critically damped. The circuit resistance to produce critical damping with the 0-1 MA range is about 50,000 ohms, and with the 0-5 MA range is about 4000 ohms.

Leads are furnished only on milliammeters in twin wall cases. DC Milliammeters may be calibrated for either left-hand zero, center zero or offset zero. Multi-range instruments are available, using either the 0-1 or 0-5 MA element. Intermediate calibrations can be supplied.

DC AMMETERS (Catalog Section 40)

Millivolts		
0-50	0-200	DC Ammeters or Millivoltmeters
0-75	0-300	with left-hand zero consume
0-100*	0-600	0.150 ampere at full scale.
0-125	0-750	
0-150	0-800	

*100 MV rating is used where we furnish both the meter and the shunt.

Response time is approximately 1 second for 0-100 MV meter. Accuracy is 1½% of full scale reading. All DC ammeters have calibrated leads 5 feet long. Normal calibration is for left-hand zero, but center zero or offset zero instruments can be supplied. Intermediate calibrations can be supplied.

FIG. 9—*Generators measure speed of steel as it is processed in electro-galvanizing line.*

DC VOLTMETERS (Catalog Section 40)

0-2
0-5
0-10
0-25
0-50
0-75
0-100
0-150
0-200
0-250
0-500
0-800

Left-hand zero meters have a resistance of 200 ohms per volt and a full scale current consumption of 5 MA. Center zero meters are 400 ohms per volt and current is 2.5 MA at either full scale point. Special high resistance voltmeters of 1000 ohms per volt can be furnished.

0-1000 }
0-1500 } For use only on grounded circuits.

Response time is approximately 0.5 second. Accuracy is 1% of full scale reading. Portable meters have 5-foot leads. Multi-range instruments can be provided. Intermediate calibrations can be supplied.

DC MILLIVOLTMETERS AND DC MILLIVOLT-VOLTMETERS (Catalog Section 40)

Range MV	Range V	
0-50	0-1	Left-hand zero meters have a full
0-75	0-2	scale current of 150 MA. Center zero
0-100	0-5	meters have a current of 75 MA at
0-125	0-10	either full scale point.
0-150	0-25	
0-200	0-50	These instruments are for use as either
0-300	0-100	a DC voltmeter, or a DC ammeter,
0-600	0-150	by combining millivolt and volt ranges
0-750	0-300	in a single instrument.
0-800	0-600	

Response time is approximately 1 second for 0-100 MV range and 0.5 second for 0-300 MV and higher ranges. Accuracy is 1½% of full scale reading. All instruments have calibrated 5-foot leads.

SPEED RECORDERS (Catalog Section 46)

A speed recorder consists of a recording DC voltmeter operated from a permanent-magnet type DC generator and calibrated in revolutions per minute, miles per hour, feet per minute, knots, processing time in minutes, etc. Accuracy of the recorder and generator is 1½% of full scale reading.

RECTIFIER RECORDERS (Catalog Section 48)

The permanent-magnet, moving-coil measuring element, with a rectifier, provides a means of recording AC and DC amperes, milliamperes and volts in a single instrument, having an evenly divided scale.

Ranges	
0-50 MA AC	Many combinations of both
0-1 to 0-10 A AC	AC and DC ranges can be
0-50 to 0-800 V AC	supplied.
0-100 MV to 0-800 V DC	

For further information ask for the Catalog Section shown.

OTHER RECORDERS

In addition to the electrodynamometer and PMMC types of recorders, The Esterline-Angus Company manufactures instruments which incorporate other types of electrically and mechanically actuated measuring elements. Most of these can be used interchangeably in all types of cases, and in conjunction with any type of chart drive.

OPERATION RECORDERS
(Catalog Section 50)

The operation recorder is a multi-pen instrument. Each pen is operated by an individual electro magnet. When the circuit to any one of the magnets is closed, the pen operated by this magnet is moved laterally across the chart about 1/10 inch from its "off" position and it remains there as long as the circuit is energized. An instrument of this type is used for recording time of occurrence, sequence, and duration of a number of events, such as opening and closing of valves, relays, doors, switches, circuit breakers and telephone circuits. It is also widely used as a production recorder, to show the active and idle periods of both automatic and manually operated equipment and processes.

One inkwell serves all pens. The pen tubes are pivoted in holes in the top of the inkwell, and engage lever arms which are linked by a spring to the electromagnets which operate the pens. A single instrument case will accommodate any number of pens from five to twenty, while twin cases will accommodate a maximum of forty pens.

Pen Coil Ratings

Minimum DC Rating—2 volts
Maximum DC Rating—250 volts
Minimum 25 Cycle Rating—3.5 volts
Maximum 25 Cycle Rating—240 volts
Minimum 50-60 Cycle Rating—6 volts
Maximum 50-60 Cycle Rating—240 volts

The power required to operate each circuit in the operation recorder ranges from 0.9 to 6.5 watts, depending upon rating.

The speed of response of the elements is such that they will follow as many as 10 complete "on-off" cycles per second, provided the "on" and "off" times are substantially equal.

Operation recorders can be operated continuously on potentials 15% below or in excess of normal rating.

PRESSURE AND VACUUM RECORDERS
(Catalog Section 60)

Permanent records of pressure and vacuum are vital guides in the operation of many types of equipment, and in the conducting of a wide variety of tests in industrial, research and development projects.

For pressure ranges from 0-25 to 0-6,000 PSI, Bourdon tube elements are used.

For pressure ranges from 0-25 inches of water to 0-15 PSI, and for vacuum, a bellows type element is used to obtain the forces necessary to operate the movement. The one-piece cylindrical brass bellows, has one side restrained while the other is permitted to move when pressure or vacuum is applied.

Ranges	Type of Element	
PRESSURE		
Minimum 0-1 PSI Maximum 0-15 PSI	—Bellows	Many intermediate ranges can be supplied.
Minimum 0-25 PSI Maximum 0-6000 PSI	—Bourdon Tube	
VACUUM		
0-30 Inches of Mercury	—Bellows	
VACUUM-PRESSURE		
30-0-30 Inches of Mercury	—Bourdon Tube	

Bellows pressure elements have a total internal volume of approximately 15 cu. in., including connecting tubing. Volume of Bourdon tube elements is approximately 1½ cu. in.

The undamped instrument will swing across scale in approximately 0.1 second. Accuracy is 2% of full scale reading.

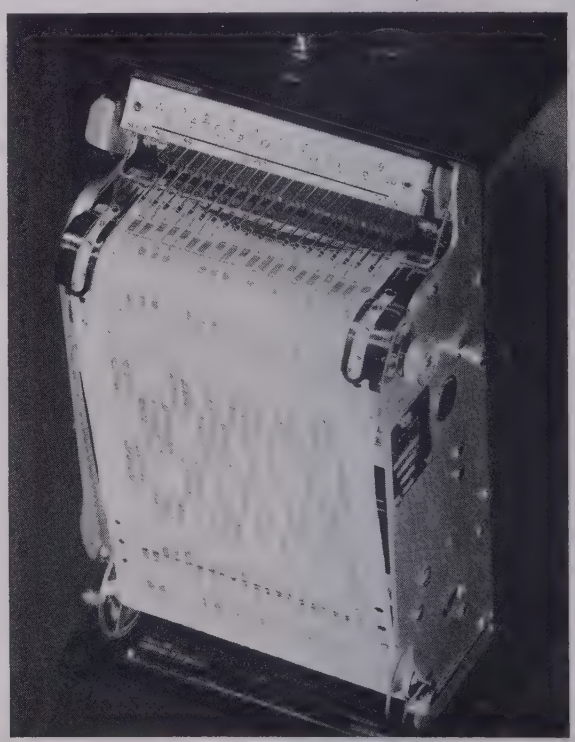


FIG. 10—*Raising the scaleplate automatically raises the pens from the chart in an Esterline-Angus Operation Recorder.*

For further information ask for the Catalog Section shown.

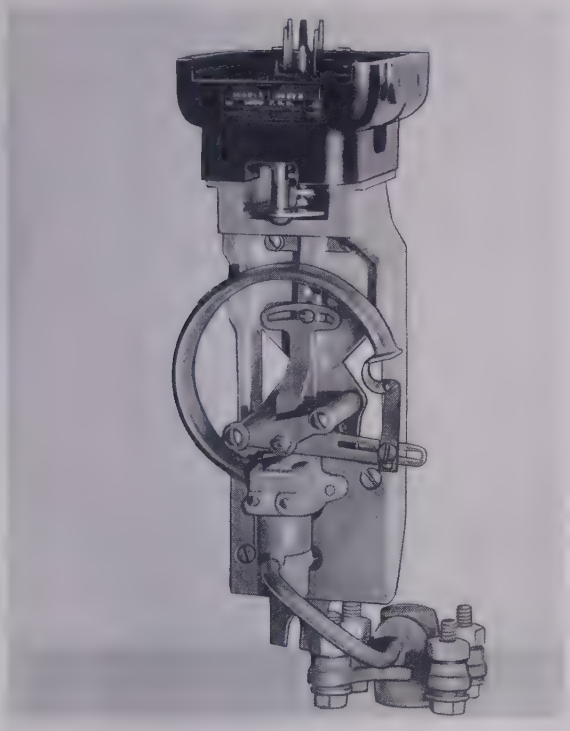


FIG. 11—*An Esterline-Angus Bourdon tube pressure measuring element.*

POSITION RECORDERS (Catalog Section 65)

These instruments are used to record position and motion of machine tool parts, molding dies, control levers, etc., and can be furnished in either a mechanical or electrical type.

In the mechanical type, the recording pen is operated by means of a rotatable shaft, projecting from the left side of the recorder case. This shaft is geared to the staff which carries the writing pen. Rotary motion can be recorded by direct gear connection to the recorder shaft. Straight-line motion can be recorded by a rack and pinion, a cable drum, or a chain and sprocket arrangement.

In the electrical type, the recording pen is geared to a Selsyn motor mounted inside the instrument, thus recording the position of a remote Selsyn transmitter, which may respond to the movement of a weighing scale, the position of lock gates, the rotation of a radar antenna, or the height of charge in a blast furnace.

Rotation of Shaft for Full Scale Deflection

Mechanical Type	Selsyn Type
Minimum—12.4°	Minimum—62°
Maximum—309.5°	Maximum—345°

Zero is usually at left side of scale. However, zero can be set at any point on the scale by shifting connection to projecting shaft. Accuracy is 0.5% of full scale rotation of external shaft on the recorder or on the transmitting Selsyn.

CONTACT-MAKING INSTRUMENTS

(Adjustable Calibrated Relays) (Catalog Section 70)

An Esterline-Angus contact-making instrument consists of a standard recorder measuring element, fitted with pointer and scale, but no writing mechanism. The measuring element carries a pair of spring-mounted moving contacts, which swing between two adjustable stationary contacts. These stationary contacts can be set at any desired maximum and minimum value on the scale. Recording and contact-making features cannot be combined in one instrument. Any of the following measuring elements can be furnished in a contact-making instrument:

AC Amperes
AC Volts
AC Watts
KVA
KVAR
Power Factor
Frequency
Speed
DC Amperes
DC Volts
DC Watts
DC Milliamperes
DC Millivolts

Contacts are rated at ¼ ampere, 250 volts maximum. Contact-making meters are usually furnished with inside adjusting levers for setting contacts. External adjusting knobs can be supplied, except on flush or portable cases.

Accuracy is the same as corresponding recorder plus 1%.

FIG. 12—*Contact-making instrument with cover removed, showing ease of adjusting contacts on direct-reading scale.*

For further information ask for the Catalog Section shown.

CHART DRIVES

(Catalog Section 20)

Of major importance in selecting a recording instrument is the method for handling the record chart at various chart speeds.

All Esterline-Angus recorders use charts 6 inches wide and 103 feet long. There are five fundamental methods of driving the chart, and more than 50 combinations or variations of these basic methods.

All chart drives are mounted on rigid aluminum frames and all have identical mounting holes. This feature makes it possible to replace one type of chart drive with another, or to exchange chart drives between instruments. The box-like construction maintains alignment of all parts, which reduces friction in the gear train, and makes possible smooth feeding of the chart.

A wide variety of standard speeds is available, covering a range from ¾″ per hour to 3″ per second. It is important to give careful consideration to the possible variations in the quantity to be measured and then select a chart speed or group of speeds which will be adequate to obtain the desired type of record.

HAND-WOUND SPRING CHART DRIVES

A hand-wound spring drive is used where electric power is not available or where the instrument must be entirely independent of any power supply.

A high quality escapement with temperature compensation provides accurate timing for 8 days with one winding of the springs at any of the hour feeds. A flyball governor controls the minute speeds, one winding providing operation for 3½ hours.

Hour feed drives provide all of the following speeds—¾, 1½, 3, 6 or 12 inches per hour.

Minute feed drives provide all of the following speeds—¾, 1½, 3, 6 and 12 inches per hour and per minute.

On minute feed drives, the shift from inches per hour to the corresponding speed in inches per minute is accomplished manually by moving a lever on the side of the drive or, where the change must be made from a remote point, the drive can be equipped with an electric gear shift.

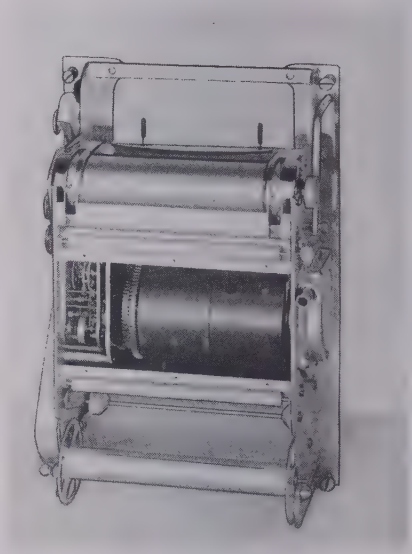


FIG. 13—*Hand-wound spring chart drive with coverplate removed, showing escapement and spring housing.*

MOTOR-WOUND SPRING CHART DRIVES

A motor-wound spring drive is applicable where AC power is available, but not regulated, or where the chart drive must keep running through a power interruption.

The chart speeds in this type of drive are controlled by an escapement and flyball governor identical with that used in the hand-wound spring drive; the chart speeds are also identical.

The power required to wind the springs in this drive is provided by a torque motor, which is intermittently energized. Motors are available for operation on 120 or 240 volts, 25, 50 or 60 cycles. A separate motor of the same type is used to power the chart reroll mechanism. Operation at any of the hour feeds will continue for approximately 5 hours after a power interruption.

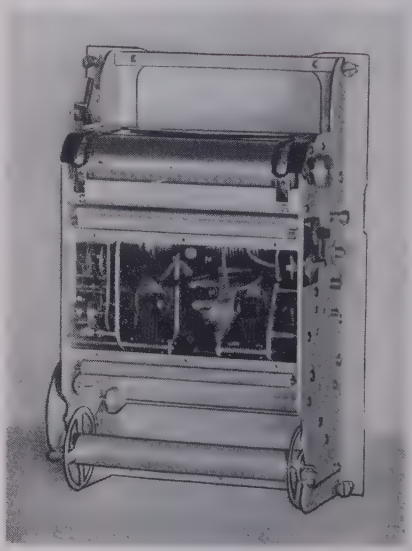


FIG. 14—*Motor-wound spring chart drive with coverplate removed, showing escapement, winding and reroll motors.*

For further information ask for Catalog Section 20.

SYNCHRONOUS CHART DRIVES

A synchronous motor chart drive is used where a source of frequency-regulated AC is available and where it is not necessary for the record to continue during power supply interruptions.

Synchronous chart drives provide all of the following speeds—¾, 1½, 3, 6 and 12 inches per hour and per minute.

The motive power in this type of drive is a self-starting, synchronous motor, which is lubricated for the life of the unit by means of an oil reservoir and felt wicks. This motor can be supplied for operation on 120 or 240 volts, 25, 50 or 60 cycles. The chart reroll mechanism is driven by a separate torque motor.

On minute feed drives, the shift from inches per hour to the corresponding chart speed in inches per minute is accomplished manually by moving a lever on the side of the drive or, where the change must be made from a remote point, the drive can be equipped with an electric gear shift.

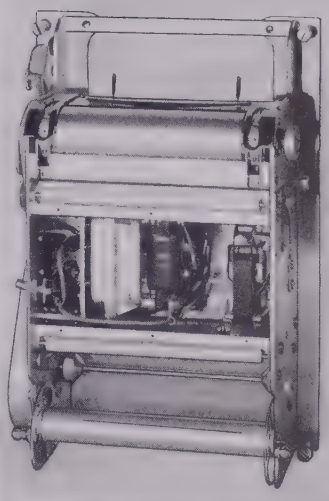


FIG. 15—*Synchronous chart drive with coverplate removed, showing timing motor, reroll motor and electric shift.*

PHANTOM CHART DRIVES

A phantom drive is one having standard chart carrying parts, but no built-in propelling power. It depends on being driven by some external device. One primary use of the phantom drive is where two meters are coupled together, as in a twin instrument. A spring or synchronous drive used in one side of the twin supplies the power and timing, and a phantom drive is used in the other.

The second use of the phantom is where chart motion is not to be proportional to time but is proportional to some motion external to the meter, such as movement of the ram on a hydraulic press, rotation of a radar antenna, or travel of a car used in checking field strength of a broadcasting station.

Standard chart movement is ¾, 1½, 3, 6 or 12 inches per revolution of the coupling shaft.

The phantom drive may be equipped with a spring-wound reroll or an electric reroll as desired.

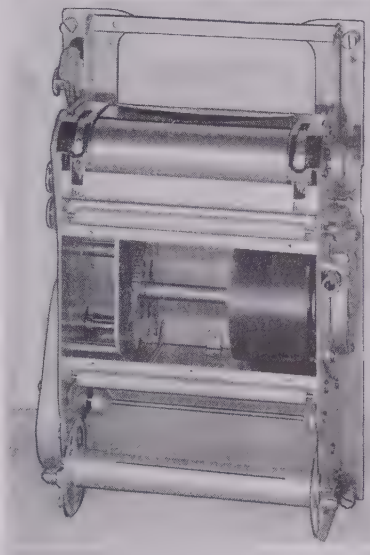


FIG. 16—*Phantom chart drive with coverplate removed, showing spring housing.*

EXTERNAL MOTOR ATTACHMENTS

Where chart speeds above 12″ per minute are desired, an external motor attachment is employed, to provide speeds of ¾, 1½, or 3 inches per second. The motor with its reduction gears and shifting mechanism is a unit assembly, and is attached to the side of the meter case. Electrical ratings are 12, 24, 48, 125 or 250 volts DC, 120 volts, 60 cycles, AC.

An external motor can be applied in combination with any of the internal chart drives described on these pages. In general, the most suitable speed is ¾″ per second, although higher speeds are available, and are necessary on certain applications.

Two forms of the external motor attachment are available. In one form, Type N, the chart advances from inches per hour to inches per second, when its motor is energized. It reverts to inches per hour any time that the initiating impulse is removed. The other form, Type R, is for fault recording. It starts in the same way but continues to run for a predetermined length of time and resets the chart to the correct time of day.

FIG. 17—*Portable instrument with external motor attachment.*

For further information ask for Catalog Section 20.

INSTRUMENT CASES

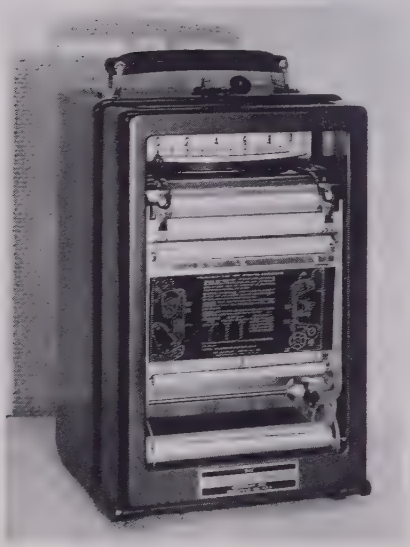
(Catalog Section 15)

Esterline-Angus instruments are furnished in four types of cases, namely, portable, flush switchboard, front switchboard and wall mounting. With the exception of the portable style, all can be furnished as twin cases.

The meter case consists of two aluminum alloy die castings, the case proper and the case cover or door. Castings of this material are light, yet tough enough to withstand rough usage.

Accurately located bosses are provided for mounting the measuring element, terminal blocks and chart drive. This makes possible the transfer of measuring elements and chart drives between cases. Such transfers can be made quickly and easily by the user, since the measuring element and drive are each unit assemblies.

All cases are finished with dull black baked enamel and all trim is heavily nickel plated and polished.



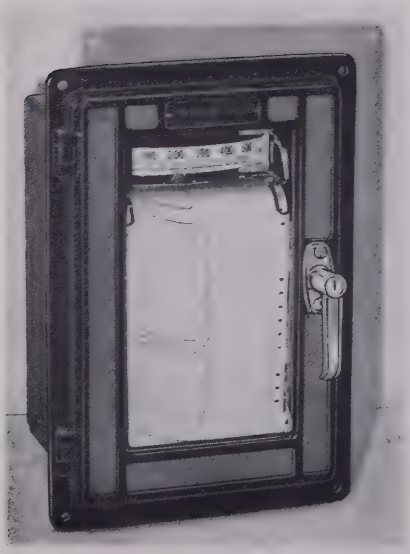
PORTABLE

A portable instrument is fitted with a steel reinforced rubber handle securely fastened to the top of the case. The entire front of the case cover is glass, and there is also a small top window, which makes the chart and scale easily visible from the front and from above the instrument. The front cover is hinged at the bottom, and is easily detached from the case.

Physical Details			Approx. Weight with Measuring Element and Chart Drive
Height*	Width	Depth†	
15¼″	8 9/16″	9 5/16″	34 lbs.

*This dimension is from the bottom of the case to the top of the handle in normal position.
†This dimension does not include multiplier. Add 2¾″ if instrument has attached multiplier.

FIG. 18—*Portable recording wattmeter.*



FLUSH SWITCHBOARD

For permanent mounting, most modern installations utilize flush switchboard cases. The case cover is hinged at the left side, and has a sturdy handle and lock at the right. The chart and scale are illuminated by a 4 watt, 120 volt, 60 cycle fluorescent lamp. On DC and 25-50 cycles, a 15 watt, 125 volt incandescent lamp is furnished.

Physical Dimensions			Approx. Weight with Measuring Element and Chart Drive
Height*	Width*	Depth†	
16″	10 9/16″	8¾″	38 lbs.

*These dimensions apply to the front flange.
†This dimension does not include multiplier. Add 2¾″ if instrument has attached multiplier. The maximum projection from front of panel is 2 5/16″.

FIG. 19—*Recording DC Milliammeter in single flush case.*

For further information ask for Catalog Section 15.

FRONT SWITCHBOARD

Front switchboard cases are arranged for front-of-board mounting with studs for rear-of-board connections on metallic or non-metallic panels of any thickness. The case front is identical with that used on portable instruments.

Physical Dimensions			Approx. Weight with Measuring Element and Chart Drive
Height*	Width	Depth	
14″	8¾″	9¼″	34 lbs.

*This dimension is from the bottom of the case to the top of the latch.

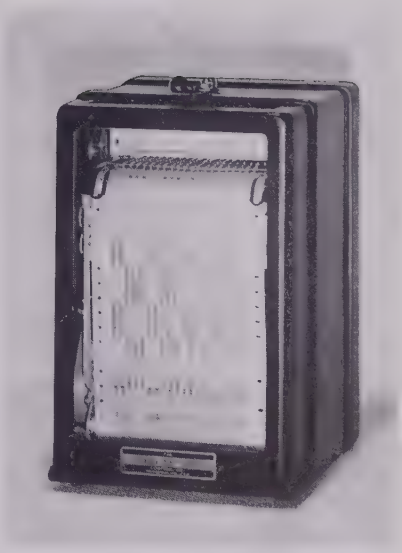


FIG. 20—*Operation Recorder in single front switchboard case.*

WALL MOUNTED

Wall type cases are arranged so that instruments can be mounted on a flat vertical surface and connections made by means of conduit, BX cable or open wiring entering from the bottom of the connection compartment. The case front is identical with that used on portable instruments.

Physical Dimensions			Approx. Weight with Measuring Element and Chart Drive
Height*	Width	Depth	
15 1/16″	8⅝″	10 15/16″	38 lbs.

*This dimension is from the extreme bottom to extreme top of mounting lugs.

FIG. 21—*Recording Wattmeter in single wall case.*

TWIN CASES

All types of instrument cases, with the exception of portables, can be provided to accommodate two standard instruments. Such an arrangement saves switchboard space, and permits the chart drives to be coupled, thus rigidly synchronizing the two records.

	Physical Dimensions			Approx. Weight with Measuring Element and Chart Drive
	Height	Width	Depth	
Twin flush	16″	19″	8¾″*	60 lbs.
Twin switchboard	14″	17½″	9¼″	60 lbs.
Twin Wall	15 3/16″	17⅜″	10⅝″	65 lbs.

*Add 2¾″ if instrument has attached multiplier.

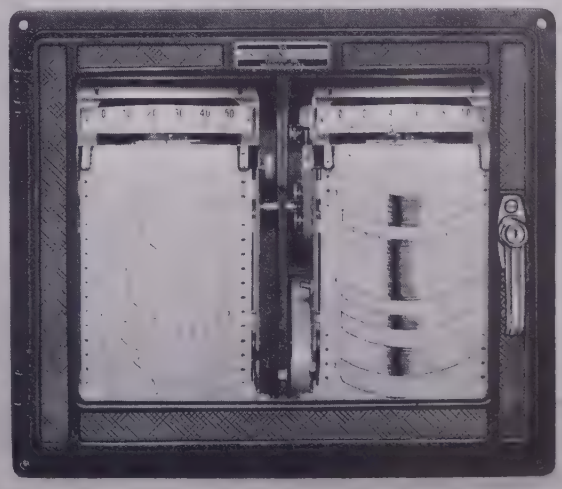


FIG. 22—*Recording Wattmeters in twin flush case.*

For further information ask for Catalog Section 15.

ACCESSORIES AND SUPPLIES

(Catalog Sections 80 and 90)

The usefulness of a graphic instrument is greatly increased through the purchase of accessory and supply items carefully matched to the recorder characteristics. Esterline-Angus instruments are required to operate under a variety of conditions, and the accessories and supplies on the following pages have been developed to have the same adaptability. Their use in combination with Esterline-Angus recorders will assure the greatest possible accuracy and dependability.

FIG. 23—*Portable 7-range Universal current transformer.*

MODEL D UNIVERSAL CURRENT TRANSFORMERS

This metal-clad transformer has primary ratings of 10, 25, 50, 100, 200, 400 and 800 amperes. Four of the ranges are obtained by means of a wound primary, and the other three ranges by looping the conductor through an opening in the core.

Esterline-Angus Universal Current Transformers are designed for use on lines up to 2500 volts, including 4000-volt star circuits with grounded neutral. They have a rating of 25 VA, and are compensated for 15 VA. They are rated for frequencies of 25-125 cycles, and under most conditions are suitable for frequencies up to 500 cycles. The net weight is 24 pounds.

For additional information ask for Model D current transformer bulletin.

SPLIT-CORE CURRENT TRANSFORMERS

Where it is impractical to open a circuit to permit the use of the high-accuracy, closed-core current transformer, split-core transformers are available in several sizes.

Rating in Amperes	Window Opening
25/50/100/200:50MA† *	1 9/16″ x 3½″
150/300/600:5*	1 9/16″ x 3½″
250/500/1000:5*	1 9/16″ x 3½″
500/1000/2000:5*	3¼″ x 4½″
1000/2000/3000:5*	4½″ x 6½″
1500/3000/6000:5	3¼″ x 6½″

*Normally carried in stock. †For use only with rectifier recorders having 0-50MA AC range.

Ratios below 500:5 are intended primarily for use with Esterline-Angus AC ammeters rated 0-5 or 0-5/10 amperes. Errors will not exceed 2%.

Ratios of 500:5 and above when used with Esterline-Angus wattmeters provide accuracy comparable with that obtained from closed core transformers. Phase angle errors may reduce the accuracy with ratios below 500:5 and particularly on circuits where the power factor is low.

For additional information ask for split-core current transformer bulletin.

FIG. 24—*Portable split-core current transformer.*

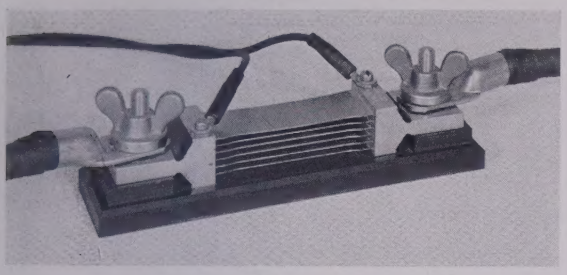


FIG. 25—*Portable ammeter and wattmeter shunt.*

SHUNTS

These fixed calibrated resistances, which are placed in parallel with a DC instrument to increase its current range, are available with capacities from ¼ to 10,000 amperes. The standard rating is 100 millivolts drop at rated current.

Due to the current drawn by the meter itself, a shunt and its leads are calibrated for the particular type of meter with which it is to be used. Use with other types of meters is permissible, but may result in awkward effective scale ranges. Shunts with a current rating 25% above full load current are recommended, to avoid possible overload.

Esterline-Angus shunts have an accuracy of 0.5%.

CHRONOGRAPH PENS (EVENT MARKERS)

In many instances the quantity being recorded is related to some other situation or event, and it is desired to key the main record with this event. Such a record can be obtained by using a chronograph pen. These pens have a lateral motion of about 1/10 inch, and record in one or both margins of the chart. (See Fig. 5.) The record is similar to that obtained by each pen on an operation recorder. They are actuated by electromagnets controlled by the event being noted.

Chronograph pens can be furnished to operate on any voltage between 6 and 250. Most ratings consume about 1.3 watts.

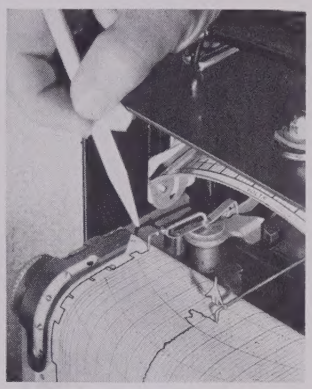


FIG. 26—*A Chronograph pen attachment provides an auxiliary record in the chart margin.*

WRITING DOOR

It is often desirable to make notes on the chart to identify portions of the record. Frequently, though, recorders are located in places where the cases must be kept closed to prevent dirt or corrosive fumes from damaging the mechanism, or must be locked to prevent tampering. For such installations, a writing door in the glass front of a meter cover can be furnished through which notes can be written without opening the cover.

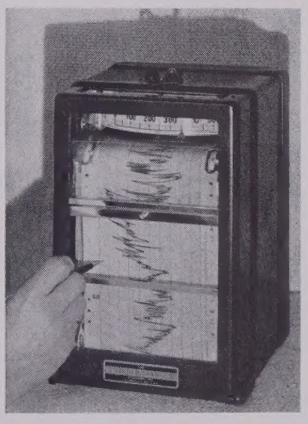


FIG. 27—*A writing door facilitates making notes on the chart.*

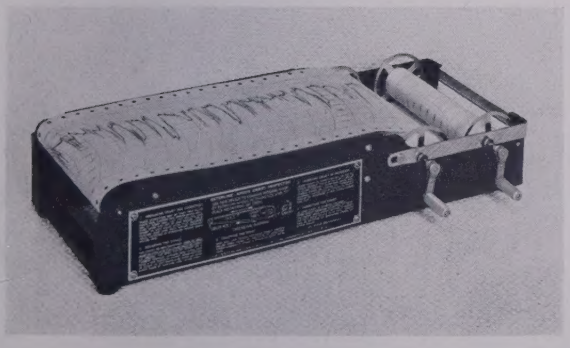


CHART INSPECTOR

A complete 103-foot chart can be placed in this device and by turning a crank the chart moves across a viewing table in either the forward or reverse direction. The chart can be inspected from end to end and when finished is rolled up ready for filing.

The inspector is well made of black enameled metal with nickel plated trimmings and has rubber feet so that it will not mar the top of a desk.

FIG. 28—*Chart inspector for reviewing records made by graphic instruments.*

CARRYING OR STORAGE CASES

For convenience in handling, and for protecting the instrument, either during transportation or storage, a carrying case can be provided. The case is made of black fibre, with hinged lid, and is equipped with a carrying handle. It is reinforced with metal corners and clasps, and is lined on the inside to prevent marring the meter case.

Two standard sizes are available. One side is for meters with or without standard attached multipliers and the other size is for meters with external motors or with large multiplier boxes.

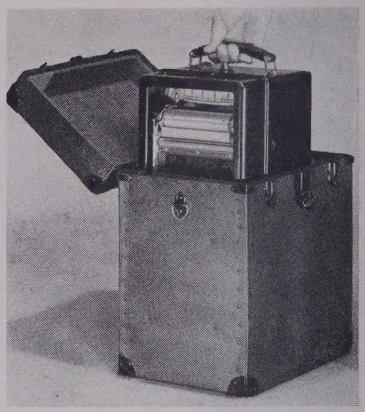
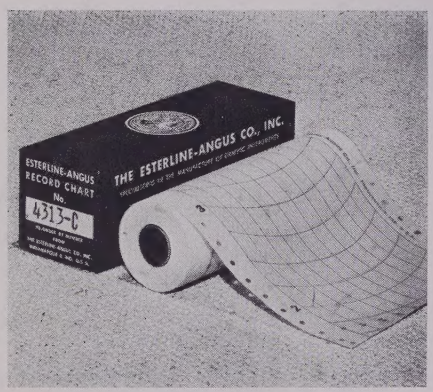


FIG. 29—*Carrying or storage case for portable instruments.*



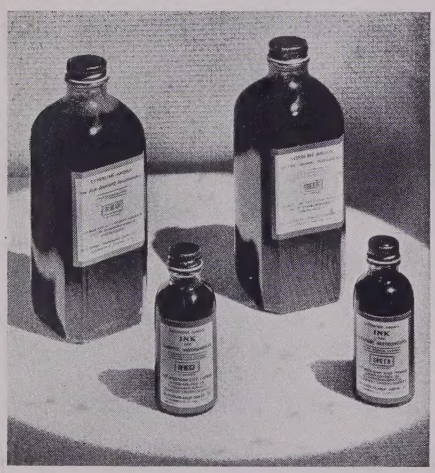
CHARTS

A graphic instrument can be no more accurate than its chart. For that reason, Esterline-Angus charts are made of a special grade of paper, manufactured exclusively for us, having the desired ink absorbing qualities and the minimum change of dimensions with changes of humidity.

All charts are 6 inches wide, the working width being 4½ inches, and 103-feet long. The printing is done in our own plant on special rotary presses designed and built by us.

Over 1100 types of charts are in stock at all times and most orders can be filled within one working day after receipt of order. Catalog Section 90 lists all standard chart ranges.

FIG. 30—*All charts are shipped in substantial boxes suitable for filing.*



INK

To few of its products has The Esterline-Angus Company given more study and attention than to the ink supplied for use in graphic instruments. Ink for this purpose has requirements which are quite conflicting. It must not evaporate rapidly in the inkwell, yet it should dry quickly on the chart to prevent blotting. It should have sufficient body to make a clear record, yet it must flow freely and not clog a fine-pointed pen. It must be suitable for use in places where temperatures are quite high, yet must not leave an insoluble residue in the well. Conversely, it must be usable at relatively low temperature.

After years of careful research, we have produced an ink which meets these demands. It is supplied in two colors, red and green and is available in two-ounce or pint glass bottles.

FIG. 31—*Esterline-Angus ink made especially for recording instruments.*

THE ESTERLINE-ANGUS COMPANY, INC.

Pioneers in the Manufacture of Graphic Instruments

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